Effects of Inflation on the Housing Market

Under Rational Expectations

by

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DISCLAIMER

I hereby declare that this thesis, which is submitted in fulfilment of the requirements for the degree of Master of Economics (by Research) at the University of Tasmania, contains no material which has been accepted for the award of any other higher degree or graduate diploma in any university. Furthermore, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except when due reference is made in the text of the thesis.

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Ph_t	=	asset price of housing at time t
Ω_t	=	information set available to agents at time t
$_t Ph^e_{t+1}$	=	the asset price of housing expected to prevail at time t+1 where the expectation is formed at time t
Hs^d	=	demand for housing services
R	=	rental demand price of housing services
y	=	household income
P	=	index of prices of non-housing commodities
hh	=	a vector of household characteristics
CA	=	credit availability
M	=	vector of mortgage characteristics
H	=	stock of existing housing units
Hs^s	=	flow supply of housing services
UC	=	user-cost of housing as percentage of asset value
i	=	nominal interest rate
i_b	=	nominal mortgage interest rate
i_o	=	opportunity cost of housing equity acquisition
x	=	rate of property tax liabilities
d	=	percentage rate of depreciation on a unit of housing stock
m	=	miscellaneous housing expenses including maintainance and repairs
g	=	rate of nominal house price inflation
	=	$(\pi^e + Ph^\bullet/Ph)$
L	=	initial loan-to-value ratio
π^e	=	expected rate of general price inflation
$Ph^\bullet$	=	time derivative of prices (dPh/dt)
$Ph^\bullet/Ph$	=	rate of real house price inflation
NH	=	rate of new housing production (gross housing investment)
$H^\bullet$	=	time derivative of the existing housing stock (dH/dt)
MP	=	initial payment on a Standard Fixed Payment Mortgage (SFPM)
DN	=	effective duration of the payment stream on a SFPM
T	=	amortisation period of a SFPM
AP	=	annual payment on a SFPM

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(Alphabetical Order)

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π^e	=	expected rate of general price inflation

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ABSTRACT

In this study an equilibrium asset-market model of the housing market is developed. The model is used to examine the effects of inflation on the Australian housing market under the maintained hypothesis of rational expectations. It provides a theoretical basis for empirically testing several hypotheses about the effects of inflation, however, the scarcity of relevant and reliable data is an important limitation, and the results are of consequential significance only.

Two streams of literature that have emerged from American research in this area are drawn together in the present study and, to that end, the theoretical model presented herein serves as a useful extension and adaptation of previous models.

Specifically, attention is directed to the influence of inflation on current housing demand decisions through: the characteristics of the mortgage instrument; the institutional features of the mortgage market; and the user-cost of home ownership.

Generation of the testable hypotheses necessiates a brief discourse on the evidence of a 'Fisher effect' in the determination of nominal interest rates in Australia. Some simple experiments are performed in an attempt to provide empirical evidence, consistent with previous cited research, of the absence of such an effect.

CHAPTER ONE: *Introduction*

1.1 INTRODUCTION

During the 1980's the Australian housing market has experienced much volatility. A significant downturn in lending for housing during 1985-86 provided a major impetus to the partial deregulation of the market for housing finance. In a bid to increase the availability of funds, from April 2, 1986 the government allowed banks to charge a market rate of interest to new borrowers. A 13.5 percent ceiling was, however, retained for existing borrowers.

After that time, interest rates began to fall and the availability of funds improved. This, together with government policy designed to stimulate housing demand, among other things, fuelled a housing boom. Lending for housing reached record levels, increasing by more than 76 percent (in seasonally adjusted terms) during the year to March 1988, and house prices soared.

Concerns that the market was over-heating led many, including the Federal government, to warn of the need to take the steam out of the property engine before it ultimately collapsed in an inflationary heap. This has been achieved in Australia's recent economic climate since high national debt has resulted in tight monetary policy and rising nominal interest rates have served to slow the housing market significantly.

The recent volatility of the market, together with the controversial debate amongst academic commentators about the deregulation of housing interest rates, [see for example: Yates, 1981a; Albon and Piggott, 1983; and Anstie et al., 1983] has generated renewed interest in the extent to which housing decisions are influenced by inflation and changes in nominal interest rates. The present study is an attempt to shed some light on this issue by examining the impact of inflation on housing demand in Australia through two channels. These are; first, the potential inflation-induced distortions that arise from general institutional features of the market for housing finance and, second, the impact of inflation on the user-cost of home ownership.

From a modelling perspective, one objective is to draw together two streams of literature that have emerged from American research in this area. A typical approach has been to specify and estimate an inverse demand function for housing and ascertain the effect of inflation through the explanatory variables in which inflationary channels have been incorporated [see Kearl, 1979; and Follain, 1982]. More recent studies have recognised the need, given the nature of the housing demand decisions examined, to look at uncertainty explicitly. This study adopts the 'typical approach' but captures the initiative of these more recent authors by applying a rational expectations approach to the issue of uncertainty and expectation formation, as exemplified in the work of Poterba (1984).

1.2 INFLATION AND THE MARKET FOR HOUSING FINANCE

There are two specific effects that inflation may have on the market for housing finance which are the direct concern of this study. The first, known as the "tilt" or "front-end-loading" problem, focuses on the interaction between inflation and the long-term Standard Fixed Payment Mortgage (SFPM) within an imperfect capital market.[1] It is argued that inflation, even when it is anticipated correctly, produces distortions in the mortgage market which, given the importance of mortgage finance to the demand for owner-occupied housing, have a sharp dampening effect on housing demand [see Lessard and Modigliani, 1975; Kearl, 1979; Schwab, 1982]. The second is through the non-price rationing of housing finance by lending institutions [see Alm and Follain, 1984; Male, 1988].

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[1] The SFPM, or constant nominal payment fully amortising mortgage, is an annuity which specifies a term, principal, nominal interest rate and constant nominal payment such that the present value of the stream of payments made by the mortgagee is equal to the amount of the loan. It is also referred to as a credit foncier loan.

That is:

$$\text{PV of stream of payments} = \sum_{t=1}^{T} \frac{R_t}{(1+i)^t} = \frac{R_1}{(1+i)^1} + \frac{R_2}{(1+i)^2} + \dots + \frac{R_T}{(1+i)^T} = \text{amount of loan}$$

where $R_1 + R_2 + \dots + R_T$ is the stream of constant nominal mortgage payments;
T is the term of the mortgage or amortisation period; and
i is the nominal mortgage interest rate.

The mortgagee's nominal payments are calculated at the time ($t=0$) when the mortgage is secured. He expects, in the absence of inflation, to pay R nominal dollars for T periods. Since the nominal interest rate is variable, the nominal repayments on such a loan change when the nominal interest rate changes.

1.2.1 The 'Tilt' Problem

Although the interpretation of the 'tilt' problem varies somewhat amongst authors, the central postulate remains that, when house purchases are financed through a SFPM, anticipated inflation will, by increasing the nominal interest rate via the Fisherian adjustment process, increase nominal mortgage payments and 'tilt' the stream of real mortgage payments towards the initial years of the mortgage (given no change in the term of the loan). This, in turn, is likely to lead to cash-flow problems for some mortgagees who are, as a result, forced to commit a larger proportion of their current income to service their mortgage.

The future path of inflation cannot be known with certainty. There is a risk implied by uncertain inflationary expectations and the SFPM shifts this risk to the mortgagee. The incorporation of an inflation premium in the nominal mortgage interest rate, together with the continued use of the SFPM, may distort the housing market as incumbent mortgagees are not freely able to adjust to different loan configurations.[2] The nature of the resulting distortion is manifested as a change in both relative prices and the rate of capital accumulation.

Figure 1, originating from the work of Tucker (1975), shows

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[2] Indeed, a remarkable feature of the Australian market for housing finance has been a failure to adapt loan contracts to changing circumstances. There has not been, for example, widespread adoption of those mortgage instruments designed specifically to overcome the problems mortgagees face because of the increased burden of debt in the early years of their contract, namely; graduated payment mortgages and shared appreciation mortgages. For a discussion of these see Yates (1983).

vividly how inflation, through its 'tilting effect', changes the real value of the quarterly mortgage payments on a 20-year, $70,200 loan bearing a real rate of interest of 6 percent [see Appendix A for the calculations upon which this graph is based].

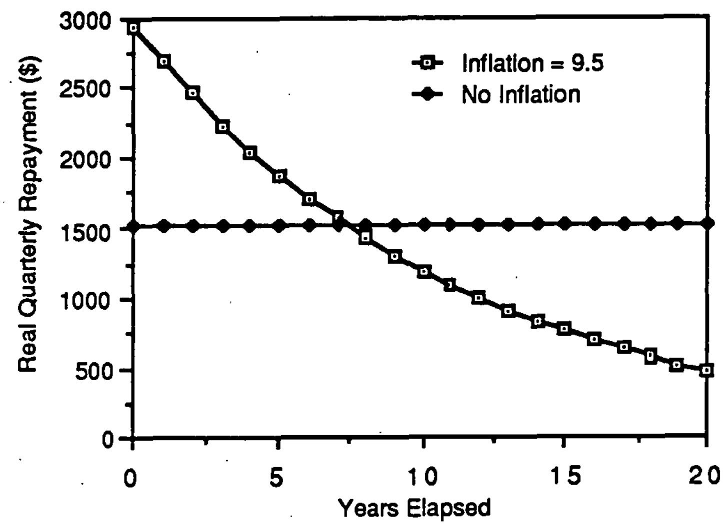

FIGURE 1
Effect of Inflation on Repayment Burden

Specifically, if inflation is anticipated, and the nominal mortgage interest rate increases through Fisher's (1954) adjustment process, then the nominal mortgage payment increases. The present value of the *real* stream of payments over the term of the mortgage (discounted at the real rate of interest) remains unchanged and the mortgagee's *real* financial position over the term of the mortgage need not deteriorate. Under the assumption of homogeneity, if prices and income change by the same proportion, the quantity of the good demanded will not change. Indeed, if anticipated inflation increases the mortgagee's nominal income by the same proportion as the increased price of owner-occupied housing, in a perfect capital market, we would expect the demand for owner-occupied housing to remain unchanged.

The tilt problem arises, however, because the mortgagee is unlikely to face a perfect capital market. The potential cash-flow problems are the result of three factors. First, imperfections in the capital market prevent the immediate delivery (with inflation) of the higher nominal income necessary to meet the higher mortgage repayments. Second, these mortgagees are typically, in the same imperfect capital market, unable to borrow in the current period against either their expected future higher nominal income or against any nominal capital gains that they expect to accrue over the term of the mortgage. Third, the mortgage contract represents a forced pattern of saving (housing equity acquisition) and therefore the incumbent mortgagees must respond in the current period with an intertemporal substitution between housing and non-housing consumption. These factors provide grounds for claiming that the effect of inflation on the demand for owner-occupied housing is inherently non-neutral. Further, the incentive that an inflationary environment provides for lenders to pass on inflation risk by using variable interest rate lending arrangements may also exacerbate the problem.

While much attention has been given in the literature to this effect of anticipated inflation, the distinction between anticipated and unanticipated inflation has been either blurred or ignored. This distinction will now be considered briefly.

Anticipated inflation refers to a rise in the general price level that is expected and is thus characterised by the market's response to this expectation. For example, if monetary authorities announced their intention to expand the money supply, market participants would anticipate an increase in the general price level and thus inflation. *Unanticipated* inflation, on the other hand, "is characterised by market phenomena implied by the alternative postulate that the contemporaneous level of prices is expected to persist." [Alchian, 1977, p.363] That is, market participants anticipate that the current general price level will prevail in the next period. In a similar example, unanticipated inflation would follow if the monetary authorities did not announce their intentions and naive anticipations were based on an information set which did not include knowledge of the ensuing monetary expansion. Actual inflation in the next period would exceed that which was anticipated, the difference representing that portion of current inflation which was unanticipated.

The tilt problem implies that inflation, even when it is anticipated correctly, can have a destabilising impact on the demand for housing in the presence of capital market imperfections. If this is the case, then there are grounds for claiming that, if some portion of the current inflation rate was unanticipated, the overall destabilising impact of inflation on the demand for housing may be more serious.

The argument here is as follows: if inflation is anticipated and if potential homebuyers act rationally, inflation will be embodied in their propensity to commit funds to the purchase of housing. Hence, an increase in the nominal interest rate, which resulted from an increase in anticipated inflation, would not come as a surprise. The potential homebuyer will be 'surprised' if actual inflation exceeds that which was anticipated. By definition, potential homebuyers will not have incorporated this unanticipated inflation into their plans.

It may be that the distinction between anticipated and unanticipated inflation is irrelevant when considering mortgagee's *ex ante* decisions whether or not to take on a mortgage. However, *ex post*, unanticipated inflation may itself have serious implications for the demand for housing.

1.2.2 Non-Price Rationing of Housing Finance

In the Australian mortgage market, two principal qualifying restrictions on the mortgage loan contract are in place. The first requires that the initial mortgage payment on a loan be no more than a specified proportion of the potential mortgagee's gross income at the time of application (25-30 percent at most institutions). The second is a limitation on the initial loan-to-value ratio and amounts to a requirement that the potential mortgagee finance the downpayment on a house purchase independently (this is usually 5-10 percent of the purchase price of the home). That is, lenders are not prepared to finance more than 90-95 percent of the initial value of the house purchase.[3]

The effect of these loan qualifying requirements is, on the one hand, to limit the number of homebuyers that qualify for a loan at all, since many will be excluded from the mortgage market on the basis of their low-income. On the other hand, those homebuyers who qualify for a loan are limited in the value of the house that they can purchase.

Credit rationing of this kind has traditionally been seen as a disequilibrium phenomenon which persists in the long run when interest rates are sticky; for example, when interest rate ceilings are imposed [see, for example, Ostas (1976)]. In contrast, the recent credit rationing literature has been concerned mainly with equilibrium rationing, a situation in which rational lender behaviour is seen as consistent with interest rates remaining at a level which implies excess demand.

Stiglitz and Weiss (1981) have argued persuasively that, in equilibrium, a loan market may be characterised by credit rationing because information is imperfect. In relation to the mortgage market, Stiglitz and Weiss would argue that, because borrowers who are willing to pay a higher rate of interest are likely to have a higher risk of default, it may not be profitable for lenders to raise interest

[3] It may be argued that, since deregulation, lenders no longer need to be as careful to assess the financial position of the potential mortgagee. The responsibility now rests more on the individual for self-assessment. Perhaps the recent experience of many Australian homebuyers who, in the face of rising mortgage interest rates, are finding themselves overcommitted, is testimony to their failure to adequately assess their own repayment capacity.

rates. This they describe as the 'adverse selection' aspect of interest rates. Hence, even in a fully deregulated market, lenders may continue to adopt non-price methods of rationing, using loan qualifying requirements to identify "good" borrowers. Nevertheless, in a regulated environment the burden of adjustment to excess demand must be borne exclusively by this mechanism.

Taken together, the tilt problem and the non-price rationing of home loans militate against the availability and affordability of housing finance and, given the importance of mortgage finance to the demand for owner-occupied housing, are likely to have an associated dampening effect on the demand for houses. The incorporation of an "inflation premium" in the mortgage interest rate through the tilt problem serves to increase the repayment burden of incumbent mortgagees and, for some homebuyers who have not yet managed to secure a loan, the increased cost of housing capital puts homeownership out of their reach since they would cease to qualify for a loan on the basis of an income test.[4]

Given that Australia has recently witnessed high rates of inflation and that the dominant mortgage instrument has been the SFPM (despite the Campbell Committee's hopes that lenders would adopt more innovative lending practices; 1981, p.643) such problems may, as Nippard (1986) suggests, have created major "inequities and

[4] For example, in order to secure a SFPM of $70,200 at a nominal interest rate of 6 percent, a household would require an annual gross income of at least $20,000. At a inflation-induced higher nominal interest rate of 16 percent, say, the same household would require an annual gross income of $39,000 to secure the same $70,200 mortgage.

inefficiencies" [1986, p.34]. The inequities are the result of the distributional consequences of restricted access to housing finance while the inefficiencies are the result of distorted resource flows and the consequent increased demands for government subsidies and assistance packages.

These arguments are of particular interest when considered in the context of a regulated market. Historically, the objectives of imposing interest rate controls have been on the grounds of both efficiency and equity. The public interest argument is often used to justify intervention on efficiency grounds because the market is distorted by lenders' monopolistic or oligopolistic behaviour. Limits on interest rates are thought to act as a countervailing force increasing the availability of funds towards the optimal level. Equity is supposedly served because limits enhance the fairness of the distribution of those funds by pricing finance at a level the less well-off can afford. The arguments above, however, suggest that interest rate regulation may fail to meet either the efficiency or equity objective.

1.3 PAST LITERATURE

Concern about instability in the housing market has originated from the American experience of the early to mid '70's when the SFPM was seen in an inflationary environment as having "... a serious destabilizing impact on both the demand for and supply of housing" [Lessard and Modigliani, 1975, p.13]. This led to a search for potential solutions to the problem comprising an examination of the possibiltiy of modifying the traditional mortgage or introducing alternative mortgage instruments [see Modigliani and Lessard (eds.) 1975; Alm and Follain, 1984].

Researchers in Australia, who also have seen the SFPM as a major culprit in the problems of housing affordability have recently adopted a similar line of inquiry [Yates, 1983; Nippard, 1986]. Although this clearly illustrates a recognition amongst Australian commentators of the ill effects of inflation in a lending environment characterized by the SFPM without perfect capital markets, there has been no published attempt to examine whether empirical research in Australia can provide evidence of these ill effects. It is useful, however, to survey relevant attempts made elsewhere.

Several writers [Kearl, 1979; Follain, 1982; Schwab, 1982; Alm and Follain, 1984] have attempted a quantitative analysis of the effects of anticipated inflation on the demand for housing when the SFPM is in place. Alm and Follain (1984) in particular, considered explicitly the qualifying requirements of the home loan contract discussed above. In this American literature it is argued that an increase in the rate of anticipated inflation affects housing demand in two offsetting ways;

(i) it *reduces* the demand for owner-occupied housing through the tilt effect; and

(ii) it *increases* the demand by lowering the real after tax user cost of owner-occupied housing as a result of the tax system's favourable treatment of owner-occupied housing.[5]

[5] For an analysis of this effect see Rosen and Rosen (1980).

The Australian taxation system does not offer deductability of mortgage interest payments and property taxes as in the USA and, therefore, an analysis of the effect of inflation in the Australian housing market can safely omit explicit taxation effects.

For the most part the empirical work on the effects of inflation on the demand for owner-occupied housing focuses on the concept of the user-cost of owner-occupation, which is analagous to Jorgenson's (1963) "user cost of capital" in the neoclassical investment literature.[6] The typical approach is as follows:

(a) integrate into a single measure the various components of housing cost, UC; nominal interest rates, i, property taxes, x, depreciation, d, miscellaneous expenses, m, and nominal capital gains, g.

That is; $UC = i + x + d + m - g$.

(b) examine the way in which inflation affects this user cost measure;

(c) specify a demand function for owner-occupied housing which has as one of its independent variables the user cost measure from (a); and

(d) deduce indirectly, through (b) and (c), the effect of inflation on the demand for owner-occupied housing.

The demand for owner-occupied housing will be inversely related to the user cost measure. Hence, if inflation increases the user cost of

6 Dougherty, A. and Van Order, R. (1982) provided a thorough derivation of such a user-cost measure.

housing capital, the demand for owner-occupied housing will be inversely related to inflation.

Kearl was the first to examine the implications of (i), above, and did so in the climate of the American housing market during the early 1970's. The central postulate of Kearl's paper was that SFPM contracts, in an inflationary environment, "increase the real cost of housing capital, leading to a fall in the demand for housing and a reduction in the relative price of housing ceteris paribus" or, as he put otherwise, "the cost of capital as usually measured will not fully account for the real cost of capital as viewed by the household" [1979, p.1116].

Kearl specified a model of the housing market which hinged on the relationship between the demand for housing services and the demand for housing as an asset. Estimation of his model provided empirical evidence to support the argument that;

> " ... given market imperfections and the traditional mortgage instrument, anticipated inflation can affect the relative price of housing. Ceteris paribus, relative housing prices fall during periods of high inflation with inflation-induced increases in the initial payment shifting demand downward." [1979, p.1125]

suggesting that the effect through (i) is large enough to offset the effect via (ii).

Follain (1982) examined the relative significance of (i) and (ii), above, and paid specific attention to the tenure choice of the household by estimating jointly a housing demand equation and a tenure choice equation. "The estimates suggest that inflation dampens housing demand and homeownership opportunity for most households even though the inflation adjusted after-tax cost of owner-occupied housing declines as inflation heats up". [1982, p.570]

Schwab (1982) presented a two-period theoretical model of the demand for housing and his simulation study based on this showed that "an increase in inflation raises the real cost of housing in the first period and lowers the real cost in the second period; the change in the demand for housing is the resolution of these two price effects" [1982, p.144] and that, with an increase in inflation, only a small loss in welfare is incurred. "It would be possible to compensate the consumer ... for an increase in expected inflation from 6.0 to 6.6 percent with a lump sum payment of only $37" [p.144]

Alm and Follain (1984), using a life-cycle model of household choice, presented simulation results which indicated that low or moderate rates of inflation (an increase from 0 percent to 5 percent) increased the demand for owner-occupied housing but higher rates of inflation decreased it.

The problem with these approaches, as Rosen, et al. (1984) have indicated, is that they centre around the construction of a series on the user-cost measure with available *ex post* data. This "implicitly assumes that households know the user-cost of housing with certainty".

> "... the ex post user cost measure exhibits substantial variability over time, and it is highly unlikely that individuals believe themselves able to forecast these fluctuations

> with certainty. Since housing decisions are usually made over time horizons of several years, this uncertainty can have important consequences for behavior. Ignoring it can lead to incorrect predictions of how people will behave under certain conditions." [1984, p.405]

1.4 RECENT LITERATURE AND THE TREATMENT OF UNCERTAINTY

The peculiar features of the housing market, which are central to models designed to examine the impact of capital market phenomena on it, are that houses are durable assets and, as such, provide both consumption and investment services and, further, that they are usually purchased with loan finance.

There are clearly two integrally related aspects of the housing market; there is a demand for and a supply of a consumer good and an investment good. The consumer good is the flow of housing services provided by the existing stock of housing capital, and the investment good is the stock of housing capital itself. Any household active in the housing market must decide on both the level of housing services required for consumption purposes and the stock of housing assets to be held for investment purposes.

As Williams (1984) suggests, "in principle the decision of how much of housing services to consume is distinct from the decision of how much housing to own" (p.144). It is the investment decision which will be most heavily influenced by the inflationary channels outlined in sections 1.2 and 1.3 above. The subsequent focus of this study is, therefore, on the demand for housing as an asset.

Implicit in this treatment, however, is the recognition of the jointness of the consumption decision. That is, prices and quantities of housing services and the housing stock demanded need to be considered as jointly determined. This notion is developed analytically in the theoretical framework of Chapter 2.

The fixed stock of housing capital at any point in time is an asset which must be held in wealth-owners' portfolios. The demand for this asset will be a function of wealth and the return on housing relative to the return on other assets competing for inclusion in the wealth-owners' portfolios. In examining this decision, the need for a model of expectations is clear because of the durability of the housing asset. The decision to invest in a house now in order to generate future income streams and services streams is based on a set of expectations concerning future prices, costs and markets. Unfortunately, a major proportion of the research cited above failed to incorporate any treatment of uncertainty and expectation formation. Rosen, et al. (1984) followed by Goodwin (1986) were the first in this strain of research to consider explicitly uncertainty and inflation risk.[7]

Rosen, et al. constructed and estimated a model of tenure choice which focused on the role of price uncertainty with respect to decisions concerning both home rental and home ownership. Their approach was to estimate an aggregate model in which the proportion of the population that owned homes was a function of the expected

[7] For a lucid exposition on recent developments in economic models of housing markets see Smith et.al. (1988).

real cost of owner occupation, the expected real price of rental accommodation and the variation of the actual prices about the forecast (the *forecast error variances*). They constructed series of expected housing prices on the basis of the ARIMA forecasting procedure suggested by Box and Jenkins (1970) and concluded from this approach that previous authors' failure to incorporate uncertainty explicitly may have led those authors to overstate the taxation effects on tenure chioce (as outlined in Section 1.3, (ii)) and, further, that "Estimates on data from 1956-1979 indicate that uncertainty over the course of relative prices has significantly depressed the aggregate proportion of homeowners" (1984, p.415).[8]

Goodwin (1986) examined the uncertainty issue in testing for the existence of hedging motives in owning housing capital. He modelled expectations of the future price of housing stock and the future price of non-housing goods as a bivariate autoregresssive (AR) process.

Both of these procedures involved calculation of expected housing prices/costs on the basis of only past values of the variables concerned. This is predicated on the assumption that the price and cost variables concerned are exogenous. If this assumption is made then the ARIMA and AR(2) processes provide the best linear forecasts which may be taken as a proxy for rational expectations. The major

[8] For example, the specific ARIMA (1,1,0) process chosen to make forecasts of P_t in year T was: $(P_t - P_{t-1}) = \Phi(T) (P_{t-1} - P_{t-2}) + u_t$, $(t=0,...,T-1)$ where P_t is the real cost of owner-occupation, u_t is a normally distributed white noise error and $\Phi(T)$ is a parameter to be estimated. Given an estimate of $\Phi(T)$, this equation "can be solved recursively to generate forecasts of the price of homeownership for as many future years from time T as desired". (p.409)

point of departure of the present study is to relax this assumption and, by so doing, incorporate a rational expectations approach to the process of expectation formation.

1.5 A RATIONAL EXPECTATIONS APPROACH

Both of the aforementioned authors noted the potential worth of formulating a rational expectations (RE) approach to the issue of uncertainty, but also suggested that a RE approach would be unlikely to yield better forecasts than their simpler approaches. This is indeed the case within the confines of their models. Nonetheless, a model designed to incorporate a RE approach would allow the uncertain variables to be forecast, not only on the basis of the past values of the variable in question, but also on the basis of a fully specified model incorporating forecasts of the variables exogenous to it. Hence, if we have grounds for claiming that housing costs and prices are determined endogenously, so too we have grounds for claiming the superiority of the rational expectations approach.

At this stage it is worth mentioning the Lucas (1976) critique. The earlier studies cited above would be seen by Lucas as having estimated the economic relationships of their housing demand models, either incorporating uncertainty or not, and then using these relationships to examine or predict behaviour under alternative scenarios. This implicitly assumes that the econometric relationships remain stable and the associated coefficients remain constant under the different scenarios. According to Lucas dynamic economic theory suggests this assumption is false. A new economic environment, he argued, would bring with it new behavioural relationships as agents adapt to the new environment by changing their forecasting schemes. This, in turn, implies that, unless the economic environment proceeds in a systemmatic and dynamically-stable manner, econometricians will be unable to provide much in the way of sophisticated policy analysis.

Invoking the assumption of rational expectations allows agents' expectations to be endogenous, but does not allow expectations to change as the circumstances governing the variables used to form them change. It does not, therefore, overcome the Lucas critique. Hence, in using the rational expectations model developed in this study to explore the consequences of a changed environment, it must still be assumed that the coefficients of the model are invariant to the changes.

Putting this critique in perspective, it would be difficult to find an area of econometric work that is not its potential victim. Econometric alternatives have been and are being developed but these involve complex procedures that are beyond the scope of the present study [see Wallis, 1980; Hansen and Sargent, 1980; and Sargent, 1981].[9] Provided that guarded and restricted interpretation

[9] Scarth (1988) has also suggested a way to get around the critique [see pp. 73-75] but adds the caveat that:

> "This answer to the critique of standard policy analysis is adequate as long as the private sector's reaction coefficients are themselves assumed to be policy invariant." (p.75)

From the microeconomic perspective of the current study this is unlikely. The concerns herein centre around responses to changes in inflationary conditions which have a very direct bearing on agents' demand decisions, since they change the constraints agents face.

of results is made in the light of new scenarios, models can be useful and should not necessarily be condemned as a result of Lucas' conclusion. Therefore, as an attempt to solve the problem raised by Lucas, this study does little to augment previous studies. It does, however, serve as a useful extension to their line of inquiry.

The difference between the approaches lies in the information assumed to be available to agents at the time that expectations must be formed. According to Rosen, et al. the "forecasts made at any given time are based only on information available at that time. (Current year prices are not included in the information set, but all lags are.)" [1984, p.408] When expectations are rational, in the sense that they represent the true mathematical expectations implied by the model, the information set upon which the expectations are conditional also includes information about the model itself and the expected values of exogenous variables. Agents in the RE model are required to make ARIMA forecasts of the exogenous variables and then to combine these with a model of asset price determination in order to be able to forecast housing costs/prices.

In its simplest interpretation the RE approach argues that the principle of rational behaviour should be applied to expectations formation. Economic agents following a maximizing strategy are said to gather current and relevant available information and utilise it in the most efficient way so as to arrive at an intelligent expectation. "The point of departure" suggested Begg;

> "... is that individuals should not make systemmatic errors. This does not imply that individuals invariably forecast accurately in a

> world in which some random movements are inevitable; rather, the assertion is that guesses about the future must be correct on average if individuals are to remain satisfied with their mechanism of expectations formation." [1982, p.29]

This proposition, under the name of the Efficient Markets (EM) model, has for some time served as the foundation of research in financial markets. The EM model, in addition to the rational expectations hypothesis, asserts that asset prices are freely flexible and reflect all available relevant information.[10]

As outlined in Section 1.4, a house is a durable asset and, as such yields a flow of services over time and may be purchased in one period for resale in a subsequent period. The housing market is also speculative in the sense that the expectation of future house prices affects the current supply and demand and hence the current asset/house price. These two elements, manifested in the jointness of the consumption and investment decisions, tailor the housing market for an application of the EM hypothesis.[11]

As it applies to housing, the EM hypothesis involves two components;

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[10] Statistical estimation of an EM model reduces the "relevant available information" to an information set which includes all lagged values of exogenous and endogenous variables of the model, the current period forecasts of all exogenous variables and the behavioural relationships of the model itself.

[11] In a very recent paper, Case and Shiller (1989) found that the market for single-family homes in several US cities (Atlanta, Chicago, Dallas and San Francisco/Oakland) did not appear to be efficient. There was a profitable trading rule to be exploited by persons who were free to time the purchase of their homes. The lack of adequate data, however, precludes a direct test of the efficiency of the Australian housing market.

(1) Expectations are rational in that economic agents are assumed to avoid making systemmatic errors in their expectations given their current information set. Further in its strict interpretation, agents' subjective expectations are given by the mathematical conditional expectation derived from the formal model.

(2) Any discrepancy between the expected rates of return on housing relative to other assets (with the same degree of risk as housing) will be quickly arbitraged so as to eliminate any expectation of super-normal profits.[12]

Taken together, these two components imply the general definitional statement that "in an efficient market prices "fully reflect" available information" [Fama, 1970, p.384] Or, in the context of the housing market; in an efficient housing market the asset price of houses will "fully reflect" available information so that if that information was available to all participants the asset price of houses would remain unaffected.

Taken in turn, (1) implies that:

$$\text{SUBJECTIVE EXPECTATION} = {}_{t}Ph^{e}_{t+1} = E\,[\,Ph_{t+1} \mid \Omega_t] = \text{MATHEMATICAL CONDITIONAL EXPECTATION}$$

[12] The existence of transactions costs, carrying costs and tax considerations and the fact that a large proportion of the assets being traded are the homes that the traders themselves live in, is evidence to suggest it may prove difficult for traders to exploit profit opportunities if, and when, they are available. In this context it may also be argued that ascertaining the degree of risk involved in a house purchase relative to other assets would prove difficult

where t = time period in question;
Ph_t = the asset price of housing at time t;
Ω_t = set of available information at time t; and
${}_tPh^e_{t+1}$ = the expectation of the asset price of housing in time t+1 formed in period t.

(2) implies that when the asset market for housing clears, agents/wealth-owners will be indifferent between holding a house or an equivalent-risk asset in their portfolios because the rates of return on each will have been arbitraged and will, therefore, be the same.

For clarification, consider a simple model of the asset demand for housing such that the asset price in any period is determined by the interaction of the demand for housing assets/units and their supply. The current asset price, Ph_t will adjust so as to induce wealth-holders to hold the existing stock of housing units, H, in their portfolios. This is the price that equates the expected return on housing with the return on other assets of equivalent risk. Clearly, given the nature of the decision of how many housing units to hold for investment purposes, the quantity of housing units demanded in the period will also be a function of the expected future asset prices. That is, expected future prices, among other things, determine the position of the current asset demand and supply functions and, therefore, the current asset price.

For example, consider a simple model of the form:

$$Qd_t = f\ \{Ph_t, Ph^e_{t+1}, \text{exog.}\}$$

$$Qs_t = g\ \{Ph_t, Ph^e_{t+1}, \text{exog.}\}$$

$$Ph^e_{t+1} = h\ \{Ph_t, \text{exog.}\},$$

where 'exog' is some vector of exogenous variables. Equilibrium (Qdt = Qst) determines Ph_t, but Qdt and Qst are themselves determined by Ph^e_{t+1}, the asset price that is expected to clear the housing asset market in the next period, which will, in turn, be a function of the asset price that is expected to clear the market in the following period. Ph^e_{t+1} thus becomes the variable that must be forecast using rational expectations so that, in the *efficient* housing asset market, the current price reflects all available information.

1.6 THE SCOPE OF THIS STUDY

Combining the discussion in sections 1.1 to 1.5 provides an outline of the concerns and scope of this study. First, the problems of interest are the potential inflationary distortions to the housing market through the tilt problem and the non-price rationing of mortgage funds. Given that these problems manifest themselves in the market for housing finance, attention is focused on the demand for housing as an asset. This approach is reasonable on the assumption that the discounted flow of the value of housing services is equal to the asset value, which governs the investment decision.

The incorporation of an explicit treatment of uncertainty in this study is of utmost importance. Attempts to do so to date have failed to recognise the endogeneity of housing costs and prices. By applying the EM model to the asset demand for housing, uncertainty is analysed within a model that is designed to allow the current asset price to be determined in response to expectations of future asset prices as well as information gathered about the past. The model developed in Chapters 2 and 3 will allow presentation of some dynamic results that may assist in quantifying the effects of inflation on the asset demand for housing.

CHAPTER TWO: *Theoretical Framework*

2.1 INTRODUCTION

Presented in this chapter is an outline of the theoretical framework through which the impact of inflation on the relative price of houses, and the size of the housing capital stock, may be analysed. Specifically, the consequences of inflation for the user-cost of owner-occupied housing as well as the tilt problem outlined in Chapter One may be examined.

The model outlined below draws together features of models developed by Kearl (1979), Poterba (1984), Goodwin (1986), Manchester (1987) and Male (1988). Poterba developed an asset-market model of the American market for owner-occupied housing. This model is adapted to suit a study of the Australian housing market and is then augmented to incorporate explicitly a channel through which inflation leads to a tilt effect. The two variables that Kearl used to capture the effects of the mortgage instrument are used, as they were by Goodwin in his study of inflation-hedging motives in housing demand.

2.2 THE ASSET-MARKET MODEL

As noted in Chapter One, a house is a durable asset that yields a stream of returns (housing services) to its owner. Housing demand is influenced by the level of returns in each period and by expected future returns. The housing asset price will then be determined at equilibrium, when quantity demanded equals quantity supplied.

2.2.1 The Market for Housing Services

Housing in this market is generally conceived as an unobservable homogeneous commodity called *housing services.* One homogeneous unit of housing stock is assumed to yield a one unit flow of housing services per time period so that houses differ only in the quantity of housing services which they possess and provide. As Sheffrin suggests "one should think in terms of the fiction that there is actually a rental market for owner-occupied housing" [1983, p.171] Hence, one can think in terms of a rental demand price for the housing services that are derived from a stock of units of owner-occupied housing. Equilibrium in the market for housing services will determine the equilibrium value of this rental demand price for a unit of housing.

The demand for housing services, Hs^d, has traditionally been expressed as a function of the rental demand price of housing services (R), income (y), an index of prices of other commodities (P), and a vector of household characteristics, (hh).[1] So that:

$$Hs^d = \phi(R, y, P, hh)$$

This is a Marshallian demand function which could be derived from a

[1] This is actually Kearl's specification but can be taken to be a general representation of the specifications that follow him in the literature. Most authors cited have used an adaptation of Kearl's model.

constrained household utility maximisation problem in which housing services appear as an argument in the utility function and housing expenditure is included as a term in the budget constraint. For example, in Male (1988), a household is assumed to maximise utility over some fixed time horizon, subject to an intertemporal budget constraint. Utility in any period depends on the housing consumption, H, and non-housing consumption, C, of the household. Thus, total utility is the discounted present value of utility in each period:[2]

$$V = \sum_{t=1}^{N} \{(1+\tau)^{-1}\}^{t-1} U(C_t, H)$$

where V = is the household's total utility over its finite time horizon;

N = the number of years in the household's planning horizon;

and τ = the household's pure rate of time preference.

Total utility is maximised subject to a budget constraint which, abstracting from bequests, requires that the present value of income be equal to the present value of expenditures on housing (including capital gains) and non-housing consumption. [Appendix B is devoted to a simplified two-period example of this type of problem to demonstrate the procedure underlying the derivation of the Marshallian demand functions]

This analysis is extended in Male (1988) to allow for capital market imperfections whereby additional constraints reflect the limits placed on households through the non-price rationing of

2 The stock of H units of housing are assumed to provide a flow of housing services that is a constant proportion of that stock over time, so that H itself appears in the household utility function.

mortgage funds and the fact that households cannot borrow in the current period against anticipated increases in real income [see also Schwab, 1982 and Alm and Follain, 1984]. Manchester (1987) captured these features in her credit availability variable, CA, and vector of mortgage characteristics, M, respectively, which appeared in her specification of the flow demand function for housing services.[3] By combining both Kearl's and Manchester's specifications, the demand for housing services may be written as:

$$Hs^d = \phi(R, y, P, hh, CA, M) \quad (2.1)$$

On the supply side, the stock of housing capital, H, that exists at any point in time will provide a flow of housing services, Hs^s. This flow, again following Kearl, may be assumed to be proportional to the stock. Thus: $Hs^s = \alpha H$

or more simply, by setting $\alpha = 1$;

$$Hs^s = H \quad (2.2)$$

Since, in the short run, the stock of housing is fixed, the flow of services from this stock is supplied inelastically and the rental price

[3] Manchester includes further influences on housing demand;

> "Further influences on housing demand include the demographic composition D of households in a local area, the quality and quantity of local services S provided by the municipal government to its residents, and perhaps the effect of climate differences in affecting the demand for housing as measured by heating degree days HD and cooling degree days CD." [1987, p.107]

but such considerations are beyond the scope and the primary focus of this study.

that is assumed to clear the services market is demand-determined. That is, equilibrium in the market for housing services requires that the rental demand price adjusts freely to equate demand for services with the stock.

From equations (2.1) and (2.2) equilibrium implies:

$$Hs^s = Hs^d$$

or

$$H = \phi\ (R, y, P, hh, CA, M)$$

and the market clearing rental demand price may be written as:

$$R = R\ (H, y, P, hh, CA, M) \qquad (2.3)$$

which is the inverse of the Marshallian demand function for housing services.[4]

It may at first seem misleading to include credit variables like CA and M in the services demand function since, *prima facie,* such variables affect the ability to 'own' housing rather than the ability to 'rent' housing. Given that this study focuses on the housing market as an asset market it is indeed concerned with the decision to own the asset housing. Notwithstanding this focus two integrally related housing markets have been identified: the market for a consumption good, housing services; and the market for an investment good, housing stock. The implicit starting point is concerned with households or

4 This is a common specification of the inverse of the Marshallian demand curve, in which demand determinants, other than the price of the good being considered, are implicitly treated as given. Thus, in the present example; y, P, hh, CA and M are given. Kohli (1986), however, has argued that, since inverse demand functions express prices as a function of quantities, a preferable specification of the inverse of the Marshallian demand curve would treat the quantities of other goods as exogenous and their prices as endogenous, rather than the reverse.

individuals considering the purchase of a housing asset. They wish to purchase that asset because it provides a flow of services which command a rental demand price and because it offers future capital gains as an investment good.[5]

A rational homebuyer, *as an owner-occupier*, should equate the price of a house with the present discounted value of its future service stream. A rational homebuyer, *intending to rent out the property*, should equate the price of the house with the present discounted value of the future rental income stream. Either way, the rental demand price determined in the market for housing services will, when equilibrium prevails in the asset market, adjust to equal the rental cost of housing (as developed in Section 2.2.2 below).

The owner-occupiers are, in principle, deciding on their demand for housing services on the basis that those services are to be supplied by the housing asset (stock of units of housing) they own. Therefore, the amount of housing stock that has been demanded for investment purposes will be a factor that determines the household's demand for housing services. Or as Struyk (1976) puts it:

> "The proposition is that given some level of stock has been demanded and obtained for investment purposes, its availability may affect the observed quantity of housing services demanded. The household in question may actually be consuming more or less services than it would in the absence of the investment consideration" [Struyk, 1976, p.28]

It is this proposition that justifies the inclusion of CA and M in the

[5] The rental demand price is an imputed rent to an owner-occupier and a market rent if the property is rented out.

inverse demand function. From the perspective of the individual purchasing a housing asset as a rental property, his/her expected future rental income stream will be also determined by his/her financial constraints.

The analysis of the housing market developed above is an equilibrium model since, at every moment, wealth-owners are willing to hold the existing stock of housing (prices change to ensure markets clear). The major concern is to explain the determination of the asset price of housing. The demand for housing services may not be reflected in the asset price if the household faces liquidity constraints or credit rationing. Hence, the model must incorporate a mechanism through which demand is limited through these features of the finance market. Essentially, what is suggested is that, if households are constrained in how much housing they can own, then they are constrained in the flow of housing services they can demand; either to provide an imputed rent to owner-occupation or a market rent. Alternatively, the constraints in the market for housing finance may be thought of as indicating a household's *effective* demand for housing services vis-a-vis its *notional* demand.[6]

2.2.2 The Demand for the Stock of Housing

A utility maximising household or individual would, as Poterba suggests; "consume housing services until the marginal value of

[6] The tenure choice problem is simplified by assuming that, in equilibrium, the rental demand prices to owner-occupiers and landlords are equalised. This may not be the case if owner-occupiers are seen to pay a premium for the "glow of ownership".

these services equals their cost." [1984, p.731] In the context of the fictional rental market for owner-occupied housing this implies that, to ensure equilibrium, the rental demand price of a unit of housing, determined in Section 2.2.1, will equate to the rental cost of providing a unit of housing. That is, an individual owner-occupier will be content to "rent" his house for a year only if it provides him with the flow of services he demands over that year. The task in this section is to explain what determines the rental cost.

The preferred approach, outlined in Section 1.3, is to focus on the concept of the user-cost of owner-occupation, which integrates into a single measure, UC, the various components of housing cost. It can be thought of as the cost, expressed as a proportion of the asset price, of buying a housing asset, holding it for a year and then selling it at the end of the year. Hence, the rental cost price of a stock of units of housing may be posited as Ph.UC where Ph is the real asset price of housing.

The user-cost measure can be disaggregated into five components; the nominal mortgage interest rate, i, the rate of property tax liabilites incurred, x, the rate of depreciation of the house, d, miscellaneous expenses including maintenance and repairs, also expressed as a proportion of asset price, m, and the rate at which nominal capital gains may accrue (the expected rate of nominal house price inflation), g. The yearly

7 The underlying assumption here is that the asset price of a house (more simply, the purchase price of a home) bears a direct correspondence to the number of homogeneous units of housing that it possesses and, in turn, its potential to provide a flow of housing services. A rational homebuyer should equate the price of a house with the present value of its future service stream.

cost of housing services provided by a stock of housing units purchased at a real price Ph is written:

$$\text{Ph.UC} = \text{Ph.}[\, i + x + d + m - g \,]$$

but this assumes that individuals are free to borrow and lend at the same nominal interest rate so that i represents both the cost of mortgage finance and the opportunity cost of housing equity acquisition. If these two rates are unequal, then the initial loan-to-value ratio, L, (the proportion of Ph financed through mortgage finance) must enter the specification of the user cost.[8] Hence:

$$\text{Ph.UC} = \text{Ph.}[\, Li_b + (1\text{-}L)i_o + x + d + m - g \,]$$

where i_b is the nominal cost of mortgage finance (the nominal mortgage interest rate) and i_o is the opportunity cost of housing equity.[9]

This is an after-tax user cost measure which differs from the after-tax user cost measures found in the literature cited [see also; Rosen and Rosen (1980) and Follain (1982)] in that it does not include tax rate terms. As noted in Section 1.3, under US tax law, homeowners are permitted to deduct mortgage interest payments from their taxable income, and some operating expenses are treated as tax allowances. This effectively reduces the real cost of home-ownership and a tax rate term is included in the user cost measure to allow for this. The Australian taxation system does not, however, make these

8 Through the nominal mortgage interest rate term, i, the assumption of the importance of mortgage finance to facilitate owner-occupation is implicit.

9 Poterba (1984) suggests this extension to the problem in fn.6, p.732.

allowances. In neither the US or Australian taxation systems are imputed rental income or the capital gains from home ownership taxed. This favourable tax treatment is retained in the present user-cost measure.

The basis of Poterba's study of real house price changes was to disaggregate the rate of nominal house price inflation and this line of inquiry is followed here. The nominal house price inflation rate, g, is defined as the sum of the expected rate of general price inflation, pe, and the rate of real house price inflation which may be expressed as $Ph^\bullet/Ph$, where $Ph^\bullet$ (= dPh/dt) is the time derivative of prices. Thus:

$$UC = [\, Li_b + (1\text{-}L)i_o + x + d + m - (\pi^e + Ph^\bullet/Ph)] \qquad (2.4)$$

Equilibrium in the asset market for housing requires that the rental demand price (services price) for a unit of housing equals the rental cost of providing an additional unit of housing. That is, in each period:

$$R = Ph.UC$$

to ensure equilibrium prevails in the asset market. This is analagous to the analysis presented by Kearl (1979) and Manchester (1987) who suggested that, given the rental demand price and the cost of housing capital, the observed point on the current asset demand function for owner-occupied housing would always be determined, in the context of the variables defined above, as:

$$Ph = R/UC$$

provided that the components of user-cost can be viewed as exogenous to the housing sector. The relationship may be rewritten as a differential equation in the asset price of housing. From (2.3) and (2.4):

$$R(H, y, P, hh, CA, M) = Ph.[Li_b+(1-L)i_o+ x + d + m- (\pi^e + Ph^\bullet/Ph)]$$

$$= Ph.[Li_b+(1-L)i_o+ x + d + m- \pi^e] - Ph^\bullet$$

$$= Ph.UC' - Ph^\bullet$$

$$\Rightarrow \qquad Ph^\bullet = - R(\ldots) + Ph.UC' \qquad (2.5)$$

where $\qquad UC' = UC + Ph^\bullet/Ph$

The dynamic behaviour of Ph therefore depends on the relationship between R and Ph.UC'. It follows that Ph changes only when there is some discrepancy between the rental demand price and the net rental cost price of owner-occupied housing, Ph.UC'. That is, Ph changes only when either R<Ph.UC' or R>Ph.UC', implying that, in equilibrium, Ph adjusts to induce optimising wealth-owners to be just willing to hold the existing stock of housing in their portfolios.

CASE 1: Ph.UC'>R

In the present model, agents make rational forecasts of future asset prices and these forecasts will influence the current asset price of housing.[10] The information set available to agents includes all lags, a model of the economic structure which affects them and expected values of the variables exogenous to the model. The maintained

[10] Alternatively, agents can be thought of as forecasting their demand for housing services in each period.

hypothesis that incumbent owner-occupiers remain content to "rent" their housing assets under circumstances when Ph.UC'>R predicates a testable hypothesis that they must be anticipating rising prices and thus $Ph^{\bullet}>0$.[11] If agents possess perfect foresight, then the actual change in real house prices will be equal to what was anticipated. If agents have rational expectations, then these will be correct 'on average'. Either way, if the current asset price is influenced by expectations of future asset prices, and if the components of UC' are determined outside the housing market, then the implied hypothesis is that agents are anticipating rising prices and are expecting capital gains to accrue to them.

CASE 2: Ph.UC'<R

The maintained hypothesis that more wealth-owners are not induced to enter the market for owner-occupied housing under circumstances when Ph.UC'<R predicates a testable hypothesis that agents are anticipating falling prices and thus $Ph^{\bullet}<0$. The expectation of capital losses discourages agents from entering the market for owner-occupied housing.

The hypotheses in the present rational expectations framework, therefore, are that the rate of change of Ph will be positive when Ph.UC'>R and negative when Ph.UC'<R. This implies that

[11] The maintained hypothesis is that agents act in a way that is consistent with their forming expectations of future house prices rationally. If agents have incomplete or insufficient information they may be discouraged from seeking owner-occupation by a relatively high rental cost price (CASE 1: Ph.UC'>R) or induced into seeking owner-occupation by a relatively low rental cost price (CASE 2: Ph.UC'<R).

the expected accrual of capital gains (or losses respectively) is enough to influence agents' current demand decisions and is borne out in the specification of equation (2.5).

Testing the null hypothesis

$$H_{01}: Ph^{\bullet}>0 \quad \text{when} \quad Ph.UC'>R$$

against the alternative

$$H_{A1}: Ph^{\bullet}<0$$

and the null hypothesis

$$H_{02}: Ph^{\bullet}<0 \quad \text{when} \quad Ph.UC'<R$$

against the alternative

$$H_{A2}: Ph^{\bullet}>0$$

can be regarded as a test of the validity of modelling the housing asset market under rational expectations.

2.2.3 The Supply of Housing Capital

In Sections 2.2.1 and 2.2.2 the demand for the existing stock of housing units was described. The task now is to analyse the evolution of that stock over time; that is, the amount of gross residential investment.

Since Ph is the real price at which builders can sell new units of housing stock, Ph can be assumed to regulate the rate of new housing production, NH (gross housing investment): NH = f(Ph); f'>0. This assumption suggests that, as the real asset price of housing increases, more resources will be allocated to the production of housing and the stock will increase. Gross housing investment will be depleted by the rate of depreciation of the existing stock, *d*H. Hence, the stock of housing units will increase over time (net housing investment) by the extent to which NH exceeds *d*H. Thus:

$$H^{\bullet} = NH - dH$$

$$= f(Ph) - dH; \qquad f'>0 \qquad (2.6)$$

which is a differential equation in the stock of housing, taken directly from Poterba's model, where $H^{\bullet}$ (= dH/dt) is the time derivative of the housing stock.

The way in which this treatment of the supply side will be utilised in the present study has one limitation. Construction firms are implicitly modelled as having upward-sloping marginal cost curves and as making construction decisions simply on the basis of the current price of their output. Thus, the supply side is modelled as static whilst, at the same time, much attention has been given to modelling the demand side as dynamic, with households being made up of forward-looking agents. Although there are clear benefits in both consistency and completeness to formulate a model that has both a rich demand side and a rich supply side it would be very difficult to do so.

Poterba was able to explore a dynamic version of the supply side, allowing construction decisions to be based upon expectations of the prices that will prevail in the future, by making use of demand side parameters estimated in other US studies. The data necessary for such an approach are not available for Australia, and, given the focus of the present study, a simplified treatment of the supply side is not considered to be a major drawback.

Equations (2.5) and (2.6) represent a system of differential equations in two endogenous variables, Ph and H:

$$Ph^{\bullet} = -R(H, y, P, hh, CA, M) + Ph[Li_b + (1-L)i_o + x + d + m - \pi^e] \tag{2.5}$$

$$H^{\bullet} = f(Ph) - dH \tag{2.6}$$

which may be used to analyse the consequences for Ph and H of an increase in the expected rate of inflation. There are two avenues through which these consequences may be experienced. First, an increase in anticipated inflation will lead to an increase in the rental cost price of owner-occupied housing by increasing the nominal interest rates that appear in the user-cost measure. Second, since mortgage characteristics have been included through the liquidity constraints and credit availability variables in the rental demand price, allowance is also made for anticipated inflation to increase the rental demand price of owner-occupied housing. This second avenue will be tailored to an analysis of the tilt problem.

2.3 THE PERFECT FORESIGHT EQUILIBRIUM PATH

Equation (2.5) incorporates the assumption of perfect foresight since the actual rate of change of real house prices is assumed to be equal to the anticipated rate of real house price inflation component of user-cost in equation (2.4). In the simple two-equation model there are two endogenous variables; the asset price of housing and the size of the housing stock. The rates of change of both of these endogenous variables depend on their levels. Thus, (2.5) and (2.6) may be represented diagrammatically in (Ph,H) space.

When there is no anticipated change in Ph then $Ph^{\bullet}=0$. The combinations of Ph and H that are consistent with $Ph^{\bullet}=0$ will define a locus of points that are consistent with steady-state equilibrium in the asset market for owner-occupied housing. This locus defines the current demand curve for housing units, when agents do not expect any capital gains (or losses) to arise from home ownership. The reasoning here comes from interpreting equation (2.5) as determining the rate of anticipated real capital gains necessary to induce wealth owners to hold the entire housing stock. $Ph^{\bullet}=0$ implies, from (2.5):

$$Ph.UC = R(H, ...)$$

That is, combinations of Ph and H that will satisfy this relationship will imply $Ph^{\bullet}=0$.

Assuming that the marginal value of a unit of housing services declines as the stock of housing expands, the rental demand price will be negatively related to the stock of housing and the ($Ph^{\bullet}=0$) locus will be downward-sloping. Neoclassical microeconomics is not in conflict with this assumption.

Holding Ph constant in (2.5), and considering a larger H value (a horizontal shift to the right of the (($Ph^{\bullet}=0$) locus in Figure 2.1) implies a fall in R and, since $R<0$, $Ph^{\bullet}>0$ and Ph is rising. Hence, to the right of ($Ph^{\bullet}=0$), Ph is rising. Similarly, holding Ph constant and considering a smaller H value (a horizontal shift to the left of the ($Ph^{\bullet}=0$) locus) $Ph^{\bullet}<0$ and Ph is falling. Hence, to the left of ($Ph^{\bullet}=0$), Ph is falling. These results are depicted by the arrows of motion around the ($Ph^{\bullet}=0$) locus. The ($Ph^{\bullet}=0$) locus is illustrated in Figure 2.1.

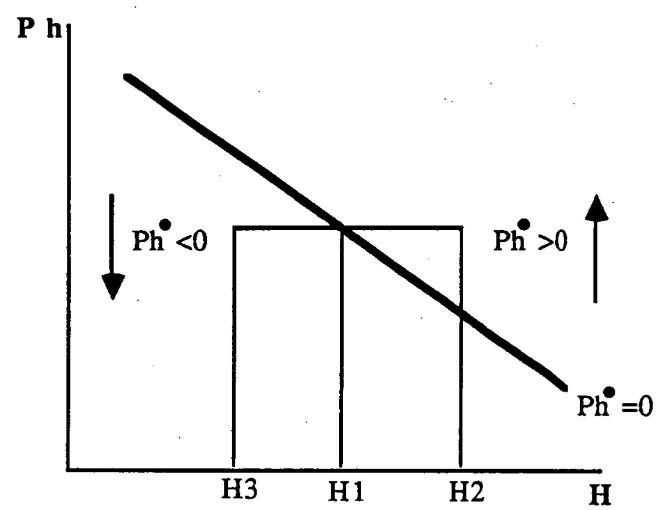

FIGURE 2.1
Arrows of Motion around the $Ph^{\bullet}=0$ locus

These arrows of motion, and the dynamic evolution of the housing market that they will imply, are derived in the context of the present rational expectations framework. That is, it is hypothesised that, if the rental cost were to exceed the rental demand price, then the change in asset prices would be positive and vice versa.

From (2.6), the ($H^{\bullet}=0$) locus is drawn in Figure 2.2 as upward-sloping by virtue of the fact that new housing construction is a positive function of the price of housing. The combinations of Ph and H that are consistent with $H^{\bullet}=0$ define a locus of points that are consistent with a constant stock of housing. The ($H^{\bullet}=0$) locus is illustrated in Figure 2.2. Holding Ph constant and considering a larger H value (a horizontal shift to the right of the ($H^{\bullet}=0$) locus in Figure 2.2) implies, since $d>0$, that $H^{\bullet}<0$ and H is falling. Hence, to the right of ($H^{\bullet}=0$), H is falling. Similarly, holding Ph constant and considering a smaller H value implies that $H^{\bullet}>0$ and H is rising. Hence, to the left of ($H^{\bullet}=0$), H is rising.

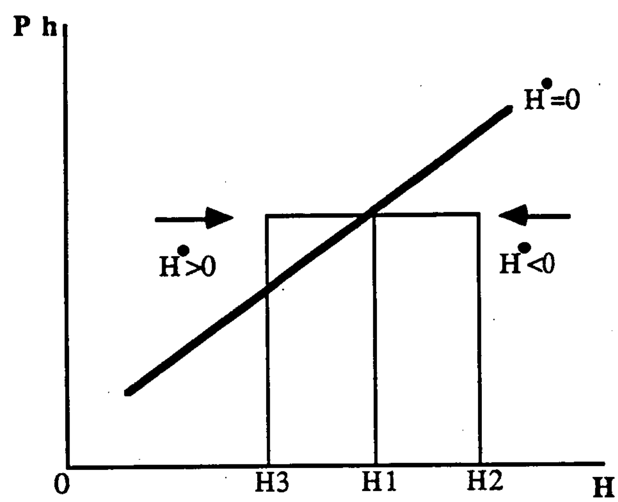

FIGURE 2.2

Arrows of Motion around the $H^{\bullet}=0$ locus

Combining the arrows of motion derived in Figures 2.1 and 2.2 yields the complete phase diagram shown in Figure 2.3. The steady-state, (Ph*, H*), is the point of intersection of the two loci at which both Ph and H are unchanging. When the economy is not in steady-state, the two loci divide the possible outcomes into four regions, each with an associated pair of arrows for the direction of change of Ph and H. Since the actual changes in Ph and H must satisfy both sets of arrows, the evolution of the housing market may be inferred.

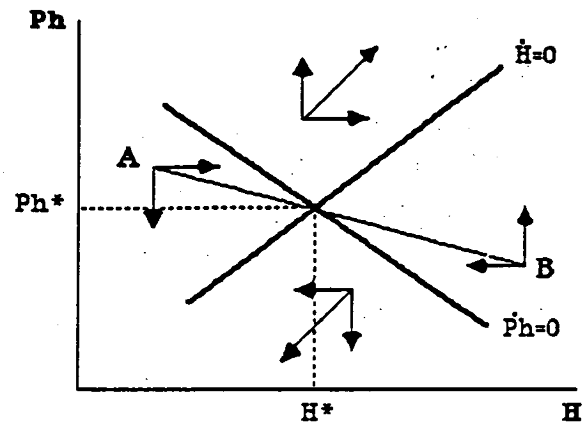

FIGURE 2.3
Phase Diagram

The appropriate arrows of motion point always towards the ($H^{\bullet}=0$) locus and away from the ($Ph^{\bullet}=0$) locus implying the steady-state is a "saddlepoint". The peculiarity of what is termed "saddlepoint instability" is that there exists a unique convergent path to the steady-state. This path is labeled in Figure 2.3 as the stable arm AB. If a steady-state is disturbed, it will only be restored if the economy begins at a point along AB. Except for disturbances of immense magnitude, convergence along this path is guaranteed with the assumption of perfect foresight or, more generally, rational expectations. The source of the saddlepoint instability lies in the assumption of perfect foresight of capital gains and losses. This assumption implies that high housing prices require prices to be rising and low prices require prices to be falling in order for the rental market to be in equilibrium.

With this background it is now appropriate to examine the dynamics of the housing market described by the above model. Chapter 3 is devoted to this task.

CHAPTER THREE: *Dynamics*

3.1 INTRODUCTION

In this chapter the task is to analyse the impact of an increase in the rate of anticipated inflation and to describe its ultimate consequences for the housing market modelled in Chapter 2. The question to answer is "What are the steady-state effects of an increase in the rate of anticipated inflation?" Since there are several ways in which inflation and inflationary expectations enter the model, an unravelling of the various channels is necessary. This also serves to extend the model in preparation for its estimation in Chapter 4.

3.2 INFLATIONARY CHANNELS

3.2.1 Channel One: Mortgage Characteristics

The model developed in Chapter 2 identifies two channels through which a change in anticipated inflation can affect the demand for housing. The first channel is through the mortgage characteristics, M, of the inverse demand function of Section 2.2.1. This variable captures the distortions induced by the structure of the Standard Fixed Payment Mortgage (SFPM). The two variables that Kearl (1979) used to describe the mortgage instrument effects were also used by

Goodwin (1986) and shall be retained here.[1] M is disaggregated into MP and DN. MP represents the initial payment on a SFPM and DN the effective duration of the payment stream. These will be considered in turn.

MP measures the initial mortgage payment and is intended to describe the 'tilt' effect discussed in Section 1.2.1. It may be expressed as:

$$MP = Ph.L.i_b / [1-(1+i_b)^{-T}] \tag{3.1}$$

where Ph, L, and i_b are as defined above and T is the term of the loan (or amortisation period) in years.[2] *A priori*, <u>through the variable MP, an increase in anticipated inflation, *ceteris paribus*, is expected to reduce the current demand for housing</u>. To recap, the inflation premium in the nominal mortgage interest rate will tilt the distribution of the real payment stream towards the beginning of the amortisation period. It is argued that, even if inflation is perfectly anticipated by households, their demand for housing will be affected adversely because they cannot trade future income for current expenditures either perfectly or costlessly. Buyers will be unable to exercise their notional demand for housing and, in the presence of non-price rationing, the availability as well as the affordability of finance may be restricted.

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1 Note that Poterba acknowledges this inflationary channel although examination of it was beyond the scope of his paper. [1984, p.731, fn.3]

2 This initial payment is calculated from the constant nominal payment on an annuity of term T where the amount of the housing loan represents the present value of the annuity. [see Appendix A]

DN is the "Macaulay duration" applied to the stream of mortgage payments. Macaulay suggested studying the time structure of a bond by measuring its average term to maturity or "duration". The resultant duration measure is the weighted average number of years until the cash flows on a bond occur, in which the relative present values of each cash payment are used as the weights. When applied to a SFPM, it can be thought of, as Kearl suggested, "as the elasticity of present value of a stream of payments with respect to the discount rate employed to calculate the present value." [1979, p.112, fn.5] In terms of the variables defined above, DN may be expressed as:

$$DN = \sum_{t=1}^{T} \{ [t. AP(1+i_b)^{-t}]/[\sum_{t=1}^{T} AP(1+i_b)^{-t}] \} \qquad (3.2)$$

where AP is the annual payment on the SFPM.

Since, with a SFPM, the nominal payment is constant, the duration is a function of the amortisation period, T, and the nominal mortgage interest rate, i_b. With an increase in anticipated inflation, which increases the initial payment on the mortgage and tilts the real payment stream, the mortgage will be paid off more rapidly and its effective duration, as defined by the variable DN, will fall. Since this means that a household's real equity in its home will grow more rapidly, the shorter duration may be expected to increase current housing demand or a least to, in part, offset the effects through MP. Thus, <u>through the variable DN an increase in anticipated inflation, *ceteris paribus*, is expected to increase the current demand for</u>

housing.

The relative impacts of inflation through MP and DN are not obvious. Goodwin (1986) discovered that both were significantly different from zero (in a statistical sense) and quantitatively large in their influence but that the duration effect only partially offset the tilt effect. Goodwin's study was consistent with the body of literature which suggests that, in an inflationary environment, the institutional features in the market for housing finance adversely affect housing demand. It also confirmed the results presented in Kearl's earlier study [see Kearl, 1979,p.1125].

In sum, previous evidence suggests that the tilt effect, through MP, outweighs the duration effect, through DN, and the resolution of these two effects leads to a dampening of current housing demand through the first inflationary channel. Given the inverse demand function for housing services in equation (2.3), this reduction in demand implies a fall in the rental demand price for housing, *ceteris paribus*.

3.2.2 Channel Two: Homeowner's User Costs

The second inflationary channel comes through homeowner's user costs. In Poterba's analysis, higher anticipated inflation rates reduced homeowners' real user costs owing to the tax subsidy to owner-occupation. For example, redefining the simple, single interest rate, user cost measure as (see section 2.2.2):

$$UC = [\ (1-\theta)(i + x) + d + m - g\ ]$$

where θ is the marginal income tax rate, allows for the deductability of property taxes, x, and mortgage interest payments from the homeowner's taxable income. Differentiating this expression with respect to the inflation rate yields:

$$dUC/d\pi = (1-\theta)\, di/d\pi - dg/d\pi$$

where $g = \pi^e - Ph^\bullet/Ph$.

Hence: $dg/d\pi = d\pi^e/d\pi + d(Ph^\bullet/Ph)/d\pi$.

Since, in the steady-state, real house prices are constant,

$$d(Ph^\bullet/Ph)/d\pi = 0$$

and $dg/d\pi = d\pi^e/d\pi = 1.$

Thus: $dUC/d\pi = (1-\theta)\, di/d\pi - 1$

and $dUC/d\pi < 0$ iff $(1-\theta)\, di/d\pi < 1$

or, equivalently, iff $di/d\pi < 1/(1-\theta)$.

Since $0<\theta<1$, $1/(1-\theta)>1$ and this implies that if nominal interest rates rise by less than $1/(1-\theta)$ percent for every one percent increase in the rate of inflation, then an increase in the rate of anticipated inflation will reduce the real user cost of home ownership. The lower user cost leads to a greater demand for housing at each real asset price.[3]

In the present model, however, the picture is different since,

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3 Poterba tests the responsiveness of the nominal mortgage interest rate to expected inflation and finds that he cannot reject the hypothesis that $d\, i/d\pi = 1$ and therefore imposes that value in his simulations. As detailed in Appendix C, such evidence was not obtained in the present study.

in Australia, interest payments and property taxes are not permissable tax deductions. The user cost expression in equation (2.4) is:

$$UC = [\, Li_b + (1-L)i_o + x + d + m - (\pi^e + Ph^{\bullet}/Ph)]$$

Differentiating with respect to inflation:

$$dUC/d\pi \;=\; L.di_b/d\pi \;+ (1-L).di_o/d\pi \;-dg/d\pi$$

where, as above, $g = \pi^e - Ph^{\bullet}/Ph$ and $dg/d\pi = 1$.

This implies: $dUC/d\pi \;=\; \{L.di_b/d\pi \;+ (1-L).di_o/d\pi\} - 1$

so $dUC/d\pi > 0$ iff $\{L.di_b/d\pi \;+ (1-L).di_o/d\pi\} > 1$,

and $dUC/d\pi < 0$ iff $\{L.di_b/d\pi \;+ (1-L).di_o/d\pi\} < 1$.

Clearly, in the present case, unless the effect of inflation on nominal interest rates can be determined, the issue of whether user cost rises or falls in response to an increase in inflation cannot be resolved.

3.3 EVIDENCE ON THE FISHER HYPOTHESIS

The best known theory of how inflation affects nominal interest rates is the Fisher (1954) hypothesis; that in the long term, the real rate of return on capital is approximately constant and the nominal rate fluctuates point-for-point with inflation. Thus the Fisher hypothesis would predict $di/d\pi = 1$. The difficulty in obtaining a series on the most important (and unobservable) explanatory variable, anticipated inflation, has traditionally hampered empirical work designed to test this hypothesis. In one recent paper, by Paul Volker (1981), this obstacle was addressed with the emergence of new survey data on price expectations.[4]

Volker investigated the importance of inflationary expectations in the determination of the nominal interest rate on 90-day commercial bills. He rigorously estimated a wide range of models over the period 1968:1 to 1979:2 and his results indicated that inflationary expectations, as depicted by the survey-based variable, although significant, were only incorporated in the nominal rate to a small extent. He found liquidity conditions to have been the major determinant of short-term interest rates in the sample period. These results appear to be inconsistent with the Fisher hypothesis.

In a more recent paper Carmichael and Stebbing (1983) claimed that much of the empirical work on the Fisher hypothesis had been misleading. They offered an alternative hypothesis which they called the "inverted Fisher hypothesis" suggesting that the nominal rate of interest, and not the real rate, is approximately constant in the long run, with the real rate moving inversely point-for-point with inflation. They tested this hypothesis for Australia using data on the 90-day commercial bill rate and a five-year industrial debenture yield and found strong support for the inverted Fisher hypothesis for both rates; results that, by definition, are

[4] The inflationary expectations variable was supplied by the Reserve Bank and was based on the Carlson and Parkin (1975) method of converting qualitative survey responses into a quantitative series. The survey responses were from the ACMA-Bank of NSW survey. There is much debate, however, about the usefulness of such survey data.

inconsistent with the Fisher hypothesis. However, Groenewold (1989) argued that the estimating equations employed by Carmichael and Stebbing were misspecified because the determinants of the nominal interest rate were supressed. Groenewold presented results, based on an explicit short-run open economy macroeconomic model, which were inconsistent with the inverted Fisher hypothesis.

A resolution of the validity or otherwise of the Fisher hypothesis for Australia is well beyond the scope of this study. The freer capital market that has emerged subsequent to the deregulation of the Australian financial system (as recommended by the Campbell Report (1981)) has brought with it a new climate in which interest rates are determined. Perhaps inflationary expectations are now reflected in movements in nominal interest rates to a larger extent. Nonetheless, until very recently, the institutional arrangements that have governed the Australian mortgage market suggest that it is likely that nominal mortgage interest rates would, in any case, have been less sensistive to inflationary expectations than purely market-determined rates.[5] Figure 3.1, below, illustrates that since 1970 the government ceiling on (savings banks) mortgage rates has frequently been binding.

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5 Again, reference is made here to the Australian government's policy initiative to remove the mortgage interest rate ceiling on new housing loans made after April 1986.

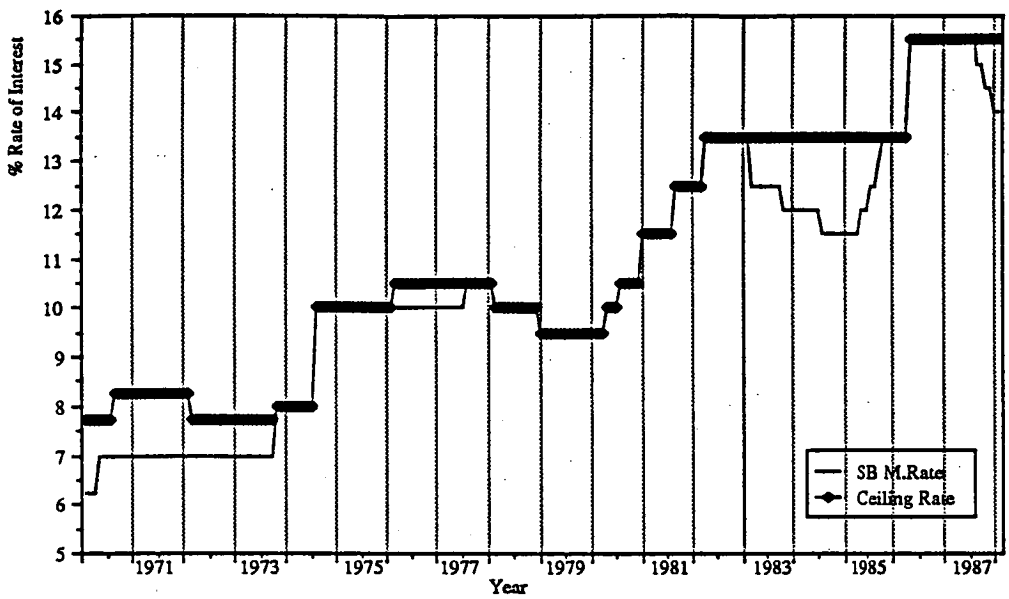

FIGURE 3.1

Comparison of Savings Banks' Predominant Mortgage Interest Rates
with the Ceiling Rate[a] January 1970 to March 1988

Source : Derived from Reserve Bank of Australia Monthly Bulletin and unpublished data

a.The ceiling on mortgage interest rates is said to be binding when the savings banks' predominant mortgage interest rate and the ceiling are equal.

In addition, when, in the regulated Australian financial market, other domestic rates were controlled, the extent to which rates such as the commercial bill rate have been 'market determined' may also be questionable. For example, if financial intermediaries received a regulated rate on their liabilities and simply needed to earn some 'satisfactory margin' above this rate, there may be little incentive for the market to adjust fully.

In an attempt to shed some light on the subject some simple but limited tests have been performed to try to establish the responsiveness of nominal interest rates to anticipated inflation in

Australia. While the institutional arrangements that have governed the Australian mortgage market suggest that the rate of anticipated inflation may not be of direct relevance to mortgage interest rates, "regression evidence provides a useful *description* of the joint evolution of mortgage and inflation rates." [Poterba, 1984, p.735] To this end Appendix C contains a report of some simple tests of the responsiveness to anticipated inflation of the nominal mortgage interest rate, the 90-day commercial bill rate and the 20-year bond rate. The results presented in Appendix C suggest that there are grounds for claiming that all three nominal rates in Australia are unresponsive to changes in inflationary expectations.

Aside from the possibility of inappropriate modelling techniques, there are a number of plausible explanations for these findings. First, the manner in which the capital market was controlled in Australia prior to deregulation militated against the full incorporation of an inflation premium into nominal rates. Second, as Williams (1979) has found, there is some evidence to suggest that, for the period of the study, the Australian public may not have taken full account of inflationary expectations when making decisions about the allocation of its wealth. This would be contrary to rational expectations if such was the case in the long run. Third, the open nature of the Australian economy may imply that Australia is an interest rate taker in world capital markets. Finally, one may, like Harrod (1973), simply not accept the view propounded by Fisher. Harrod makes the point that:

> "... cash and bonds are both denominated in money. The rate of interest on bonds is the cost of going out of bonds into money, or, to put it the other way, it is the premium one receives if one goes out of money into bonds. It is, so to speak, the rate at which money exchanges for bonds. Since neither of these assets contains a hedge against inflation, it is not logical to affirm that the emergence of a sure prospect of inflation can alter the rate at which they exchange with each other. What is not logical cannot be accepted into the corpus of economic theory." [1973, p.71]

Harrod conceded the prospect of the influence of a firm expectation of inflation only to the extent that it would alter the relative valuation of assets that provide no hedge against inflation, like bonds, and those that do, like equities and real estate. Although full exposition of Harrod's reasoning has not been given here, it remains that there are plausible reasons for not expecting nominal interest rates to fully reflect the rate of anticipated inflation.[6]

The evidence presented in this section and Appendix C, albeit limited, suggests that assuming:

$$\{L.\mathrm{d}i_b/\mathrm{d}\pi + (1\text{-}L).\mathrm{d}i_o/\mathrm{d}\pi\} < 1 \quad \text{and} \quad \mathrm{d}i_b/\mathrm{d}\pi < \mathrm{d}i_o/\mathrm{d}\pi$$

is reasonable. Furthermore, $\mathrm{d}i_o/\mathrm{d}\pi$ is likely to be less than one since there are grounds for claiming that nominal interest rates in Australia do not rise point for point with inflation. Typically, L lies

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6 Harrod suggests a compromise himself:
"The commonly held view is that it is the certainty, or strongly held belief, that inflation will proceed at a certain rate that is reflected into the interest rate. I suggest, on the contrary, that it is uncertainty about what may happen as regards inflation that can affect the interest rate." [1973, p.73]

in the range ($0.8 < L < 1$) and this implies, from Section 3.2.2, that $dUC/d\pi < 0$ and lower homeownership user costs will, *ceteris paribus*, lead to an increase in current housing demand.

3.4 THE NET EFFECT OF INFLATIONARY CHANNELS

It remains to establish whether the mortgage instrument (Channel One) or user cost (Channel Two) effects on the housing market are more significant. Through the first inflationary channel anticipated inflation is likely to reduce housing demand and, through the second, to increase housing demand. Unless the relative magnitude and impact of these two channels can be determined the *net* effect of anticipated inflation on the demand for housing cannot be established.

There are three possible outcomes: **Outcome** (a), in which the mortgage characteristic effects dominate the user cost effect; **Outcome** (b), in which the user cost effect dominates the effects of the mortgage characteristics and; **Outcome** (c), in which the two channels act in equal and offsetting ways so as to leave the current demand for housing unchanged. In Sections 3.4.1 and 3.4.2 the comparative dynamics of the first two outcomes are examined.

3.4.1 Outcome (a): Channel One Dominates Channel Two

Suppose there is an increase in the rate of anticipated inflation. If channel one dominates channel two then the net effect will be for this to reduce the demand for housing. The effects illustrated in Figure 3.2 would ensue.

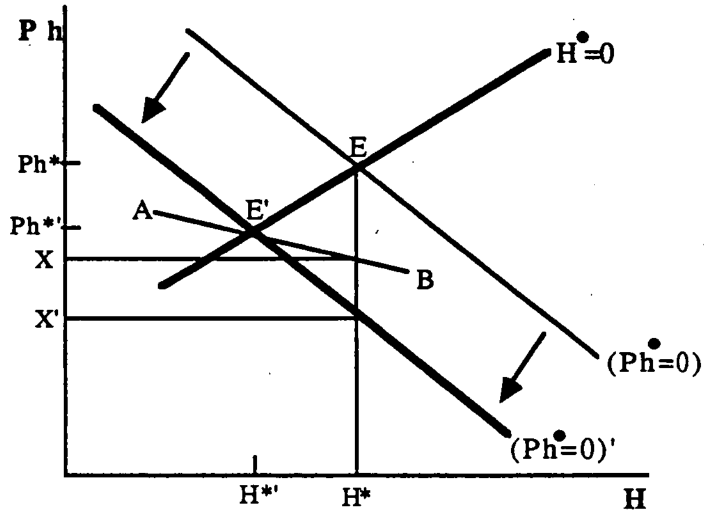

FIGURE 3.2

Outcome(a): Channel One Dominates Channel Two

The ($Ph^{\bullet}$=0) locus would shift to the left to ($Ph^{\bullet}$=0)' because it is effectively the current demand curve for housing when there are no anticipated capital gains. The asset price of housing will immediately fall to the point X on the stable arm AB at the existing stock of housing H*. The economy moves along the stable arm to a new steady-state equilibrium at E'. On the path to E' asset prices increase and the housing stock decreases as gross housing investment, NH, declines in response to the price fall from Ph* to X.

Agents in the housing market, with perfect foresight, know that prices will be increasing on the path to the new steady-state, since the fall in gross housing investment decreases the stock of housing units. Because agents actually expect to reap capital gains, the asset price does not fall to X' in response to the increase in inflation. The decrease to X' is the change in the asset price that would ensue if agents expected the stock of housing units to remain fixed. That is, if agents failed to recognise that housing stock adjustments will accommodate the initial change in asset prices.

The new steady-state, E', is characterised by a lower asset price, Ph*', and a smaller stock of housing units, H*'.

3.4.2 Outcome (b): Channel Two Dominates Channel One

The second possible outcome is simply the counter example to Outcome (a). That is, if the reduction in user-cost increases housing demand to a greater extent than housing demand falls through the mortgage characteristics effect, then the $(\dot{Ph}=0)$ locus will move to the right to $(\dot{Ph}=0)'$ as illustrated in Figure 3.3.

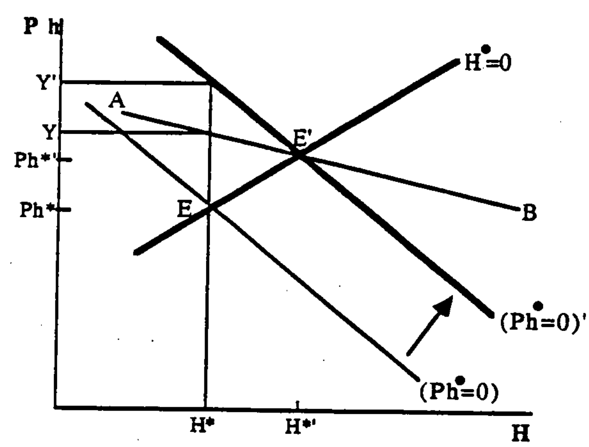

FIGURE 3.3

Outcome(b): Channel Two Dominates Channel One

The asset price of housing will immediately rise to Y on the stable arm AB at the existing stock of housing H*. The economy will then move along AB to the new steady-state E'. On the path to E' asset prices decrease and the housing stock increases as gross housing investment, NH, increases in response to the price rise from Ph* to Y. Agents in the housing market, with perfect foresight, know that prices will be falling on the path to the new steady state since the increase in NH accompanying the initial increase in asset price to Y increases the stock of housing. Because the agents actually expect to make capital losses the price does not increase to Y' in response to the increase in anticipated inflation. The increase to Y' is the change in the asset price that would ensue if agents expected the stock of housing units to remain fixed.

The new steady-state, E', is characterised by a higher asset price, Ph*', and a larger stock of housing units, H*'.

Referring back to the analysis of Chapter 2, under rational expectations it has been hypothesised that, if the rental cost of home ownership exceeds the rental demand price (CASE 1, section 2.2.2), then the rate of change of the asset price of housing will be positive. This is represented as the null hypothesis $H_{0\,1}$. Similarly, if the rental demand price exceeds the rental cost (CASE 2, section 2.2.2), the rate of change of the asset price of housing will be negative. This is represented as the null hypothesis $H_{0\,2}$.

Under Outcome (a), the fall in the rental demand price induced by an inflationary shock exceeds the accompanying fall in the user-cost of home ownership. Thus, Ph.UC'>R and $Ph^{\bullet}>0$. Thus, Outcome (a) is a restatement of $H_{0\,1}$. Similarly, under Outcome (b) the fall in the user-cost induced by an inflationary shock exceeds the accompanying fall in the rental demand price implying, in correspondence to Case 2, Ph.UC'<R and $Ph^{\bullet}<0$. Thus, Outcome (b) is a restatement of H_{02}.

These results are borne out in Figure 3.4 which illustrates the path of house prices as predicted by the two outcomes.

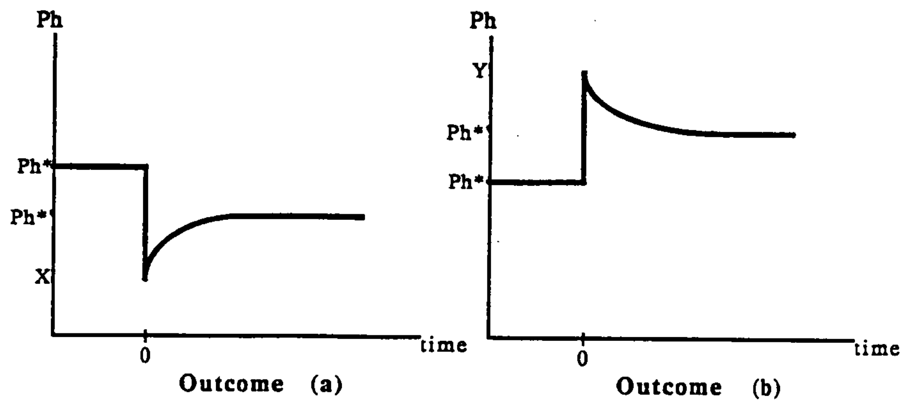

FIGURE 3.4
Path of Real House Prices as Predicted by Outcomes (a) and (b)

Time t=0 represents the initial steady-state, E, and the time at which the inflationary shock is posited to occur.

The task in estimating the empirical model, as developed in Chapter 4, will be to provide grounds for choosing one outcome over the other which is equivalent, in light of the above discussion, to testing H_{01} against H_{A1} and H_{02} against H_{A2}.

CHAPTER FOUR: *Empirical Model*

4.1 INTRODUCTION

The objective in Chapter 4 is to obtain estimates of the parameters of the theoretical model presented in Chapters 2 and 3 using recent Australian data. This will assist in quantifying the relative magnitudes of the impact of inflation on the housing market through its two channels, as identified in Chapter 3.

To that end, the model must be solved to yield a system of equations that may be estimated using Australian quarterly time series data.

4.2 MODEL USED FOR ESTIMATION

In the theoretical framework of Chapter 2, an inverse demand function for housing services was identified and represented in equation (2.3). Extending the analysis to include the demand for housing as an asset, it was suggested that, to ensure that equilibrium prevails in the asset market, the rental demand price, R, of a unit of housing will adjust to equal the rental cost of providing an additional unit of housing, Ph.UC. Thus:

$$Ph = f\,(\,R,\ UC\,)$$

where $$R = R\,(H, y, hh, CA, M) \tag{2.3}$$

and $$UC = [Li_b + (1-L)i_o + x + d + m - (\pi^e + Ph^{\bullet}/Ph)] \tag{2.4}$$

Hence, the inverse demand function may be written as;

$$Ph = f\,\{H, y, hh, CA, M, [Li_b + (1-L)i_o + x + d + m - (\pi^e + Ph^{\bullet}/Ph)]\} \tag{4.1}$$

where Ph is the real asset price of housing. Note that in Section 3.2.1 two variables were identified; MP, the initial mortgage payment, and DN, the effective duration of the payment stream. These variables will be used to capture the mortgage characteristics term, M.

On the supply side, the model was developed with the assumption that Ph would also regulate the rate of new housing production since Ph is the real price at which builders can sell new units of housing stock. The underlying assumption is that the housing construction industry is perfectly competitive so that industry supply depends simply on its output price. This leads to the specification of a construction supply function that models the rate of gross investment in new housing in each Australian State capital city as being determined by Ph, the real price of houses in that city.[1]

The line of inquiry that Poterba (1984) explores, which

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1 This is in direct contrast to Poterba's empirical work which centered on estimating the construction supply function rather than the inverse demand function. Poterba's supply function was thus relatively complex. Since the primary interest in this study lies in estimating the demand side parameters, a more complex demand side is specified along with a simplified supply side. Clearly, it would be favourable to have rich specifications of both demand and supply but time constraints prevent this.

acknowledges that construction decisions must themselves be based upon expectations of the prices that will prevail some months into the future, is not explored in the present study. A simplified modelling procedure is employed in that, although the demand side is assumed to require modelling that takes explicit account of its dynamic nature, the supply side can be modelled adequately as if it is static. That is, consumers respond to past and present information, whereas producers utilise only current information. This is not considered to be a major problem because quarterly data is used and the time involved in building a house rarely exceeds three months.

In preliminary experiments the impact of two other variables on the flow of new construction was examined. These variables were; the real price of alternative construction projects; and construction costs (including the relative price of inputs and the prevailing real award wage in the construction sector). However a simultaneity problem emerges in such specifications, since it is likely that the movement in construction costs would be demand determined. That is, increased demand for housing units would be likely to bring with it increased demand for inputs and upward pressure on input prices. This implies that increased input prices may not be accompanied by a diminished flow of new construction, since the rate of new construction is influenced by output prices which are responsive to increased demand. A further difficulty was that data on a suitable proxy for the real price of alternative construction projects (for example a non-residential construction deflator from the national accounts) was not available across individual states. Other attempts to devise such a proxy proved inadequate. This was not a cause for great concern since the extent to which factors are substitutable between alternative projects of this type is unclear. The simple specification of construction supply was thus;

$$\text{Gross investment} = NH = g\,\{Ph, D_1, D_2, D_3\} \quad (4.2)$$

where D_1, D_2 and D_3 are seasonal dummy variables. From first-stage estimation of equation (4.2), the differential equation in the stock of housing (equation 2.6) may be utilised to generate a series on the estimated housing stock, $H^\wedge t$. This series is, in turn, included as an explanatory variable in the inverse demand function given in (4.1).

$$H^\wedge_t = H_{t-1} + NH^\wedge_t - dH_{t-1} \quad (4.3)$$

Since the housing stock is to be measured in terms of the number of dwelling units and not as the value of the stock, the depreciation of the stock should equal the number of residential demolitions in each quarter. It is assumed that these constitute a negligable proportion of the stock so it is defensible to set the parameter *d* equal to zero.[2]

To facilitate consistent parameter estimation, the model is

2 It is consistent to retain a measure of depreciation on the demand side of the model, whilst at the same time assuming the absence of depreciation on the supply side, since the former represents a proportion of the value of the stock of housing units owned by the household.

specified as follows (note that the signs attached to the parameters are those hypothesised in Chapter 2). Utilising a linear functional form for (4.1) and (4.2) the following model is obtained:

$$Ph_t = -\alpha_1 H^{\wedge}_t + \alpha_2 y_t + \alpha_3 hh_t + \alpha_4 CAt - \alpha_5 MP_t - \alpha_6 DN_t$$
$$- \alpha_7 UC'_t + \alpha_8 \pi h^e_t \quad (4.4)$$
$$H^{\wedge}_t = H_{t-1} + NH^{\wedge}_t \quad (4.3)$$
$$= H_{t-1} + \beta_1 Ph_t + \beta_2 D_{1t} + \beta_3 D_{2t} + \beta_4 D_{3t} \quad (4.5)$$

where πh^e_t is the expected rate of real house price inflation defined as: $({}_tPh^e_{t+1} - Ph_t)/ Ph_t$

and is analagous to $Ph^{\bullet}/Ph$, and $UC'_t = [Li_b + (1\text{-}L)i_o + x + d + m - \pi^e]$ is that part of the real user-cost measure that may be considered to be exogenous. Equation (4.4) is a discrete time version of the inverse demand function in (4.1). Substituting (4.5) into (4.4) yields:

$$Ph_t = -\alpha_1(H_{t-1} + \beta_1 Ph_t + \beta_2 D_{1t} + \beta_3 D_{2t} + \beta_4 D_{3t}) + \alpha_2 y_t + \alpha_3 hh_t$$
$$+ \alpha_4 CAt - \alpha_5 MP_t - \alpha_6 DN_t - \alpha_7 UC'_t + \alpha_8 \pi h^e_t$$
$$= -\alpha_1 H_{t-1} - \alpha_1\beta_1 Ph_t - \alpha_1\beta_2 D_{1t} + \alpha_1\beta_3 D_{2t} + \alpha_1\beta_4 D_{3t} + \alpha_2 y_t$$
$$+ \alpha_3 hh_t + \alpha_4 CAt - \alpha_5 MP_t - \alpha_6 DN_t - \alpha_7 UC'_t + \alpha_8 \pi h^e_t$$
$$\Rightarrow \quad Ph_t (1 + \alpha_1\beta_1) = j Z_t + \alpha_8 \pi h^e_t$$
$$\Rightarrow \quad Ph_t = j/(1 + \alpha_1\beta_1) Z_t + \alpha_8/(1 + \alpha_1\beta_1)\pi h^e_t \quad (4.6)$$

where Z_t is a (10x1) matrix in which all the k exogenous variables; H_{t-1}, D_{1t}, D_{2t}, D_{3t}, y_t, hh_t, CA_t, MP_t, DN_t and UC'_t, have been stacked and j is a (1x10) row vector of coefficients on the exogenous variables contained in Z_t.

That is,

$$\underset{(1\times 10)}{j} = \begin{bmatrix} \alpha_1 & \alpha_1\beta_2 & \alpha_1\beta_3 & \alpha_1\beta_4 & \alpha_2 & \alpha_3 & \alpha_4 & \alpha_5 & \alpha_6 & \alpha_7 \end{bmatrix}$$

$$\underset{(10\times 1)}{Z_t} = \begin{bmatrix} H_{t-1} \\ D_{1t} \\ D_{2t} \\ D_{3t} \\ y_t \\ h\,h_t \\ CA_t \\ MP_t \\ DN_t \\ UC'_t \end{bmatrix}$$

The notation ${}_tPh^e_{t+1}$ is used to denote the expectation, formed in period t, of Ph_{t+1}. Agents have been assumed to form these expectations rationally in the sense that all information available, up to and including the present, is used in forming expectations about future economic events. [see section 1.5]. The expectation is conditional on the information set, Ω_t , which in the present case contains information analagous to the structure of the economy (that is, the model) and knowledge of past values of the exogenous and endogenous variables therein. Ωt is assumed to be available and utilised by agents in forming expectations regarding Ph_{t+1}. That is:

$${}_tPh^e_{t+1} = E\,[\,Ph_{t+1} | \,\Omega_t] = Ph_{t+1} - \eta$$

where η is a random vector that is uncorrelated with the information set Ω t. Under the assumption of perfect foresight (there is no uncertainty) $_tPh^e_{t+1} = Ph_{t+1}$. Substituting for πh^e_t, equation (4.5) may be approximated as:

$$Ph_t = j/(1+\alpha_1\beta_1)\,Z_t + \alpha_8/(1+\alpha_1\beta_1)\Delta \log Ph_{t+1} \qquad (4.7)$$

because:

$$\begin{aligned}\Delta \log Ph_{t+1} &= \log(Ph_{t+1}) - \log(Ph_t)\\ &= \log(Ph_{t+1}/Ph_t)\\ &= \log[(Ph_t + Ph_{t+1} - Ph_t)/Ph_t]\\ &= \log[1 + (Ph_{t+1} - Ph_t)/Ph_t]\\ &\approx (Ph_{t+1} - Ph_t)/Ph_t\end{aligned}$$

for values of $(Ph_{t+1} - Ph_t)/Ph_t$ that are small. This is a convenient transformation which allows the model to be represented as a linear semilog function. From equation (4.7), and the assumption that expectations are formed rationally, it is clear that Ph_t depends on the expectation of Ph_{t+1}. This expectation may be found by recognising that it is based on the known structure of the model.

4.3 CONSISTENT ESTIMATION USING INSTRUMENTAL VARIABLES

In the present rational expectations model, the explanatory variable, Ph_{t+1}, reflects values of the dependent (endogenous) variable that are expected to prevail in the future. Since this implies that one of the explanatory variables is contemporaneously correlated with the disturbance, it poses the statistical problem that:[3]

$$\text{plim}\{(1/n)(X'u)\} \neq 0$$

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[3] See Johnston (1972), pp. 271-281.

where n is the sample size;
X is the (nxk) matrix of explanatory variables; and
u is the (nx1) column vector of disturbance terms.

Since, $\text{plim}\{(1/n)(X'u)\} = 0$, is a necessary condition for the consistency of the least-squares estimator, application of the Ordinary Least Squares estimator to the present model is inappropriate. Consistency is an important property of an estimator because it guarantees that the estimates it yields will improve as sample size increases. That is, the sampling distribution of the estimator will tend to become concentrated on the true value of the parameter as sample size increases. An alternative method of estimation, which is known to give consistent estimates in this case, is the method of instrumental variables.

McCallum (1976) suggests an instrumental variables technique to provide consistent estimates of parameters in models that incorporate rational expectations. In the context of the present problem, this amounts to eliminating the unobservable variable, Ph_{t+1}, using an instrumental variable. A brief outline of the theory underlying the use of this technique follows.

Assume that the exogenous variables of the model are generated by a vector autoregressive stochastic process that does not depend on the process determining the endogenous variable Ph_t. For example:

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \dots\dots\dots\dots + \phi_p Z_{t-p} + \varepsilon_t$$

is a vector autoregressive process of order p where ε_t has a mean of zero and is serially uncorrelated. Consistent with the concept of rationality, the current period expectation of next period's price has been defined as:

$$ {}_{t}Ph^{e}_{t+1} = E\,[\,Ph_{t+1} \mid \Omega_t] = Ph_{t+1} - \eta $$

and Ω_t is generated by, at least, the present and past values of the variables included in the model. That is:

$$ \Omega_t = [\,Z_t\,,\ Z_{t-1}\,,\ Z_{t-2}\ \ ,\,..........\,, Z_{t-n}\,;\ Ph_t\,, Ph_{t-1}\ \ , Ph_{t-2}\ \ ,\,.......\,, Ph_{t-n}\,; ...\,] $$

Now, if the conditional expectation of Ph_{t+1} is linear, then it may be written as a linear function of the variables contained in Ω_t.

$$ \begin{aligned} E\,[\,Ph_{t+1} \mid \Omega_t] &= \delta_0 Z_t + \delta_1 Z_{t-1} + ... + \delta_n Z_{t-n} + \gamma_0 Pht + \gamma_1 Ph_{t-1} + \gamma_2 Ph_{t-2} \\ &\quad + ... + \gamma_n Ph_{t-n} \\ &= Ph_{t+1} - \eta \end{aligned} $$

Hence, Ph_{t+1} may be written:

$$ \begin{aligned} Ph_{t+1} = {} & \delta_0 Z_t + \delta_1 Z_{t-1} + ... + \delta_n Z_{t-n} + \gamma_0 Pht + \gamma_1 Ph_{t-1} + \gamma_2 Ph_{t-2} \\ & + ... + \gamma_n Ph_{t-n} + \eta \end{aligned} $$

The model given by equation (4.7) may, therefore, be estimated using the instrumental variable technique with the instrument for $\Delta \log Ph_{t+1}$ being the estimated vector of $\Delta \log \hat{} Ph_{t+1}$ which is generated from the regression of $\Delta \log Ph_{t+1}$ on a vector of instruments selected from the information set Ω_t.

The method of instrumental variables involves a search for a new variable $\Delta\log^{\wedge}Ph_{t+1}$ that is both highly correlated with $\Delta\log Ph_{t+1}$ and is, at the same time, uncorrelated with the error term in the equation of the model to be estimated. The exogenous variables in the model will serve as instruments because their appearance in the model suggests that they are correlated with Ph_t and they are exogenous (or predetermined) and are therefore uncorrelated with the error term. Given the assumptions, the necessary conditions for the application of McCallum's instrumental variables technique will be satisfied. Estimation of the model given by equation (4.7), using the instrumental variable $\Delta\log^{\wedge}Ph_{t+1}$ will therefore yield consistent parameter estimates.

4.4 DATA AND PARAMETER ESTIMATION

The model given in equation (4.7) was estimated, using quarterly data for the years 1980:1 to 1988:4 inclusive, across the six Australian State capital cities as well as for Australia in aggregate. Although much of the data was available monthly, some was available only quarterly. Some of the data requirements could not be met for Canberra or Darwin so these cities were omitted from analysis.

There is no freely published data relating to Australian house prices. The real price of housing in each State capital city was represented by the median price for established houses in that city, as estimated by the Real Estate Institute of Australia (REIA), divided by the Consumer Price Index, excluding the housing expenditure class, for each city in each quarter (ABS unpublished data). Although the

REIA does not estimate median house prices for Australia in aggregate, a measure was derived in the current study by weighting the capital city prices using population data from the ABS.

The data that was made available by the REIA was not ideal in that it represented median house prices in each city and it was not possible to ascertain the distribution of house prices on either side of the median value. Indeed, the fact that the data utilised was available for only the capital city in each State, means that other data used in the analysis, that was available only on a State-wide basis, was not strictly comparable. Unfortunately, this limitation could not be overcome in the short run.

The stock of owner-occupied housing units in each city, in each quarter, was determined using the first-stage predicted number of new dwelling commencements in the State during the quarter. These predictions were used to augment and deplete the known number of occupied private dwellings in each State obtained from the census of 30th June, 1986. The results of the first-stage estimation are given in Table 4.1. Since the equations displayed first-order autocorrelation, they were estimated using the Cochrane-Orcutt procedure. In each case the dependent variable is the number of new private sector residential dwelling commencements in each State obtained from ABS building-activity data. Encouragingly, when comparing the predicted housing stock for the June quarter of 1981 with the reported stock from the census of that year the error was less than 3 percent in every case.

Table 4.1

First-Stage Estimated Coefficients

		Sydney	Melbourne	Brisbane
Ph	β_1 =	5.322	13.553	12.673
		(3.344)	(4.425)	(7.036)
		[1.591]	[3.063]	[1.801]
D_1	β_2 =	0.099	0.428	0.675
		(0.345)	(0.225)	(0.231)
		[0.286]	[1.905]	[2.926]
D_2	β_3 =	1.247	0.714	0.951
		(0.389)	(0.253)	(0.268)
		[3.207]	[2.824]	[3.555]
D_3	β_4 =	0.585	0.718	0.940
		(0.350)	(0.225)	(0.237)
		[1.668]	[3.197]	[3.959]
Constant	β_0 =	5.866	0.475	2.416
		(2.705)	(2.290)	(3.253)
		[2.169]	[0.207]	[0.743]
R^2		0.782	0.798	0.795
$\bar{R}^2$		0.757	0.774	0.772
Rho		0.010	-0.187	0.311
DW		1.956	2.371	1.336

		Adelaide	Perth	Hobart*
Ph	β_1 =	3.679	3.920	0.552
		(2.049)	(2.867)	(0.554)
		[1.795]	[1.367]	[0.996]
D_1	β_2 =	0.233	0.296	0.038
		(0.087)	(0.132)	(0.030)
		[2.679]	[2.244]	[1.270]
D_2	β_3 =	0.219	0.536	0.053
		(0.101)	(0.153)	(0.035)
		[2.167]	[3.495]	[1.506]
D_3	β_4 =	0.291	0.245	-0.033
		(0.089)	(0.137)	(0.032)
		[3.278]	[1.794]	[-1.006]
Constant	β_0 =	0.551	2.582	0.680
		(0.930)	(1.408)	(0.225)
		[0.593]	[1.834]	[3.022]
R^2		0.801	0.759	0.559
$\bar{R}^2$		0.778	0.731	0.708
Rho		-0.209	0.029	-0.073
DW		2.335	1.912	2.145

*only 19 observations available

Table 4.1 continued...

AUSTRALIA

Ph	β_1 =44.309
	(13.244)
	[3.346]
D_1	β_2= 1.558
	(0.674)
	[2.311]
D_2	β_3= 3.684
	(0.766)
	[4.809]
D_3	β_4= 2.730
	(0.686)
	[3.982]
Constant	β_0= 6.640
	(7.653)
	[0.868]
R2	0.825
$\bar{R}2$	0.805
Rho	0.117
DW	1.763

Note: Dependent variable in each case is NH = the number of new private sector residential dwelling commencements; standard errors appear in parentheses and t statistics appear in square brackets.

The desired income measure was real median disposable permanent household income, by State capital city. This was represented by the quarterly equivalent of estimated median weekly family income figures provided by the REIA. Clearly, there are limitations in using this income measure, not the least of which is that it takes no account of the effects of taxation over the sample period. It was used, however, because a better income measure could not be found in the time available for the project.

The variable hh was used to capture demographic characteristics since, as Jaffee and Rosen (1979) and Hendershott (1980) have emphasised, households with different demographic characteristics have sharply different homeownership rates. For example, results of the Survey of Housing Occupancy Costs (ABS, 1980) indicated that only 4.1 percent of households with head under 25 years of age were in the process of purchasing their own home, compared with 14.3 percent of those with head between 25 and 29 years, 20.1 percent of those with head between 30 and 34 years and a 61.5 percent rate amongst older household heads. Hendershott also suggested that this variable may capture, in part, the declining impact of financial constraints on older families who have experienced equity gains. In the absence of time series data on the proportion of households with head aged 25 to 34, the proportion of the total population aged 25 to 34 in each State was included as an explanatory variable in the inverse demand function. Unfortunately, this information was only available by State on an annual basis (ABS unpublished data), and it was necessary to interpolate between the annual observations, by fitting a log-linear function to the available data points, to approximate a quarterly series.

CA, credit availability, is seen by many as an important determinant of the demand for owner-occupied housing, given the importance of mortgage finance to realising a planned house purchase.[4] This suggests that poor credit availability could reduce housing demand. Two credit availability measures were incorporated into this study. The first, CA_1, represents the change in Savings Bank and Permanent Building Society deposits, by State, divided by the average value of a new housing loan across those lenders in that State.[5] This measure is similar to that used by Manchester and is intended to represent the number of "average" loans that could be made available in the quarter given the increase in funds (liabilities) available to be offset by new assets. The second measure of credit availability, CA_2, was reported by Hendershott as the average change in deposits in the previous two quarters divided by the price of a constant-quality house. Since data on the latter was unavailable, the average value of a housing loan in the current period in each State was used in the denominator instead. This second measure of credit availability is close to that used by Jaffee and Rosen (1979).

MP was measured as the initial real quarterly mortgage payment on a SFPM on an average loan (as used in calculating CA) for the State, given the State's current quarter's predominant nominal mortgage interest rate and based on a loan with an amortisation period, T, of 20 years.[6] Since credit availability from both Savings

4 There is, however, much controversy regarding this issue. While Jaffee and Rosen (1979) have reported results of a very large impact of credit availability on the demand for housing, De Rosa and Meltzer (1978) could find no impact.

5 As Permanent Building Societies and Savings Banks dominate the lending for housing, the calculations can be based solely on these lending sources. The increase in Permanent Building Societies' deposits was represented by the change in their borrowings from the private sector i.e. withdrawable share capital and unsecured borrowings (Source: ABS Cat.No. 5617.0 and 5637.0).

Banks and Permanent Building Societies (PBS) was to be incorporated, it was necessary to approximate an average nominal mortgage interest rate by quarter by using Savings Banks' mortgage interest rates, as reported in the Reserve Bank of Australia's monthly Bulletins, and State-specific PBS nominal mortgage rates. A weighted average rate was then calculated using the proportion of the total housing loans in the quarter made by each type of lender as weights. An alternative measure for MP was the quarter equivalent of the average monthly loan repayment provided by the REIA. This variable is denoted AQLR in the tables presented below.

Measurment of the nominal mortgage interest rate is a significant limitation to the quantitative analysis. Australian financial markets have been deregulated only recently. The nominal mortgage interest rate charged by Savings Banks on new housing loans was subject to a 13.5 percent ceiling for the larger part of the sample period and it is thus only the most recent 11 observations (from 1986:2, when the ceiling was lifted, to 1988:4) that would truly capture the effects outlined in chapters 1-3. However, if the study was restricted to this small number of observations, the sample period would be clearly inadequate.

A further reason for concern about the use of Savings Banks mortgage rates in the analysis is the fact that, under regulation, the existence of the "cocktail loan" commonly made the *effective* cost of

[6] Male (1988) has argued that at times when the availability of credit is poor, particularly in periods when the ceiling on mortgage interest rates has been binding, potential mortgagees have been rationed out of the mortgage market through non-price means.

housing finance from Savings Banks higher than the regulated rate implied. The term "cocktail loan" was used in the early 1980's to describe the loan package provided by banks who, unable to compete for deposits, had very little money to lend. They financed a small proportion of a housing loan at the artificially low rate of 13.5 per cent and the remainder with a personal loan, at a much higher rate of interest.[7] The result of this was that the *average* cost of housing finance was quite close to the then market rate of interest.

The suggestion that the nominal mortgage interest rate, which has been measured in this study as a weighted average of the rates charged by Savings Banks and Permanent Building Societies over the sample period, may be understated has implications for the variables that have been derived on the basis of this rate, when interpreted with reference to the arguments of the the previous chapters, would be biased. For example, in the 'tilt effect', intended to be captured by the variables MP and DN, the flexibility of nominal interest rates is implicitly assumed.[8]

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[7] This part of the loan package, upon which a much higher rate of interest was charged, was commonly financed by the bank's finance company affiliate.

[8] This limitation is not as crucial to the results for the variable UC' since, in the discussion of Sections 3.2.2 and 3.3, the small positive responsiveness of Australian nominal interest rates in an inflationary environment, ceteris paribus, was canvassed. Indeed, the suggestion there that; $\{ L di_b/d\pi + (1L) di_o/d\pi \} < 1$ led to the hypothesis that inflation would enhance housing demand by delivering more in terms of capital gains through nominal house price inflation than it did to an increase in the exogenous user-cost component. This, in turn, implied the expected coefficient signs; $\alpha_7 < 0$ and $\alpha_8 > 0$.

DN was calculated for an amortisation period of 20 years, as used in MP, but using the annual payment on a SFPM for an average loan value for the State.

Finally, a time series on UC', homeowner's exogenous real user costs, was constructed. To proxy the unobservable expected rate of general price inflation, an ARIMA(0,1,1) model was fitted to a data series on actual quarterly price inflation for each State capital city to generate one-period-ahead forecasts of the inflation rate for each city [as in Appendix C]. d , the rate of depreciation of the house, has been, in most studies, assumed to accrue at some fixed proportion of the purchase price of the house and that tradition is retained here. To represent x , the rate of property tax liabilities incurred, and m, miscellaneous expenses including maintainance and repairs, use was made of the expenditure classes; "Local government rates and charges" and "House repairs and maintainance" and "House insurance" of the Housing sub-group of the Consumer Price Index, respectively (ABS unpublished data). The percentage rate of change of these indices was calculated for each State and used to adjust an assumed annual 2.0 percent rate of depreciation and 2.5 percent maintainance costs.[9] The initial loan-to-value ratio was again taken as 0.80, with i_b the weighted average nominal mortgage interest rate across savings banks and permanent building societies in the State. i_o , the opportunity cost of housing equity, was proxied

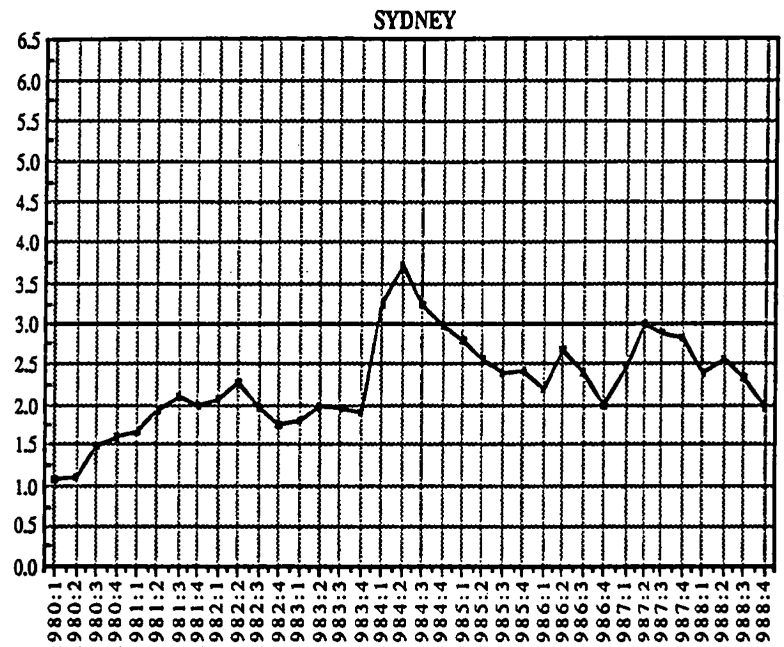
[9] Prior to March quarter, 1987, the sub-classes "House repairs and maintainance" and "House insurance" were published as a composite series "Other home ownership".

as the long-term bond rate. The constructed series on UC' for each State Capital city are plotted in the Figure 4.1.

FIGURE 4.1

Real Exogenous User-Cost (% of asset price):

by State Capital City[a]



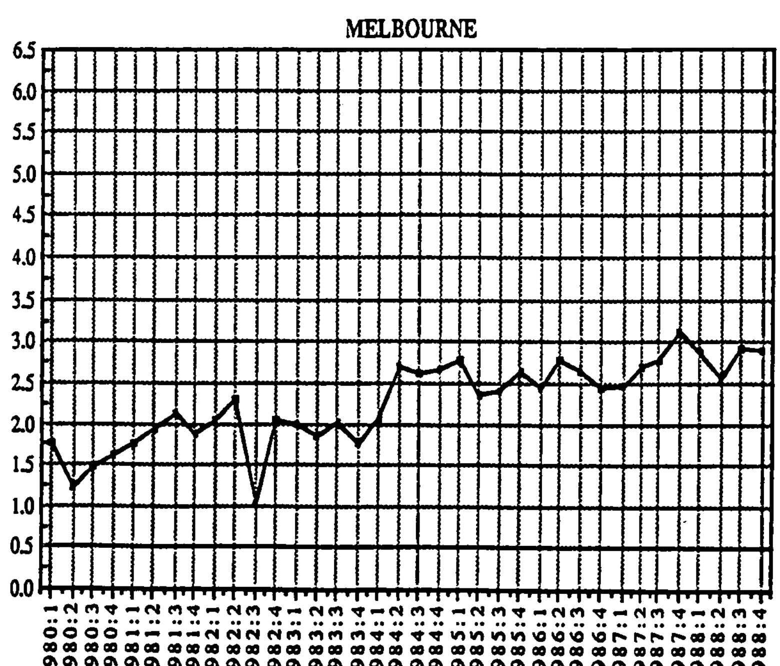
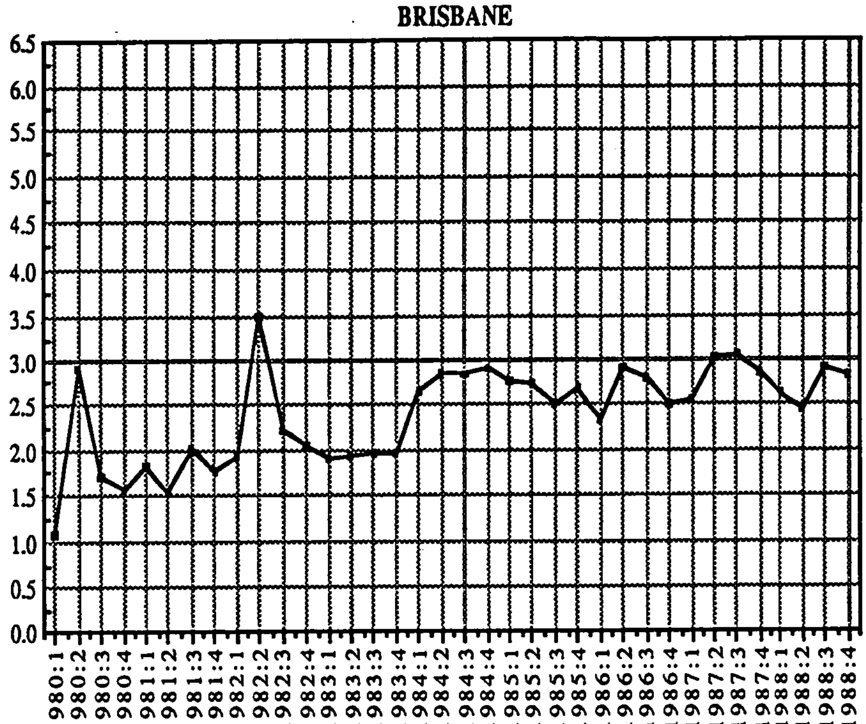


FIGURE 4.1 continued ...



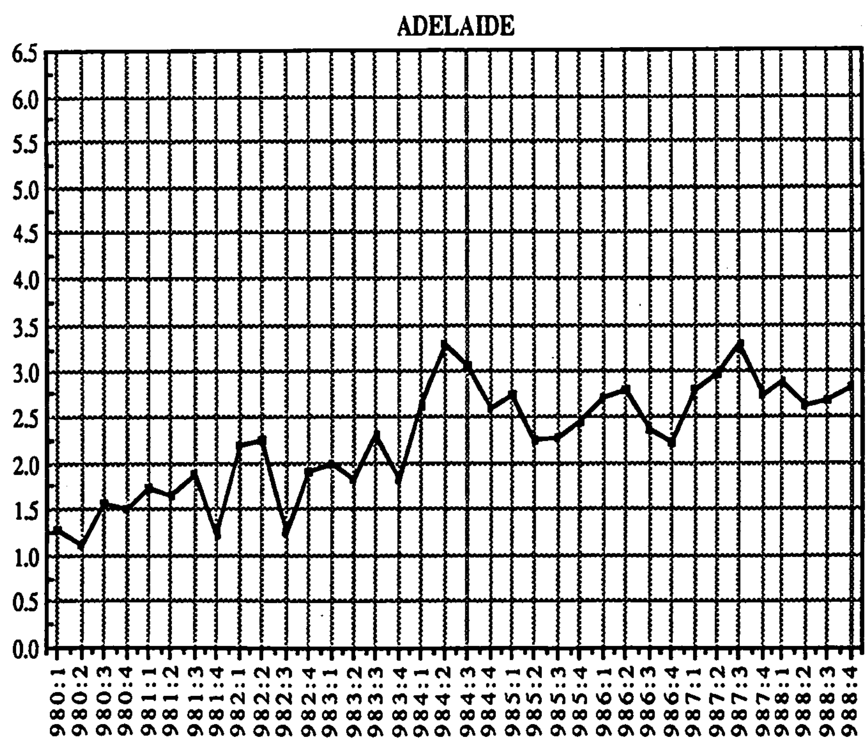
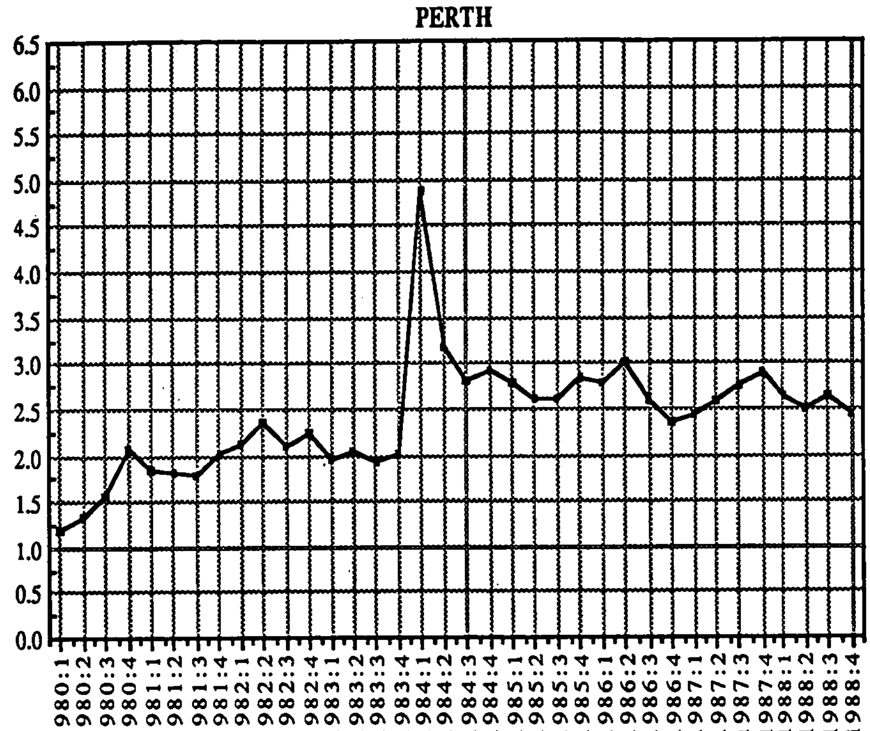
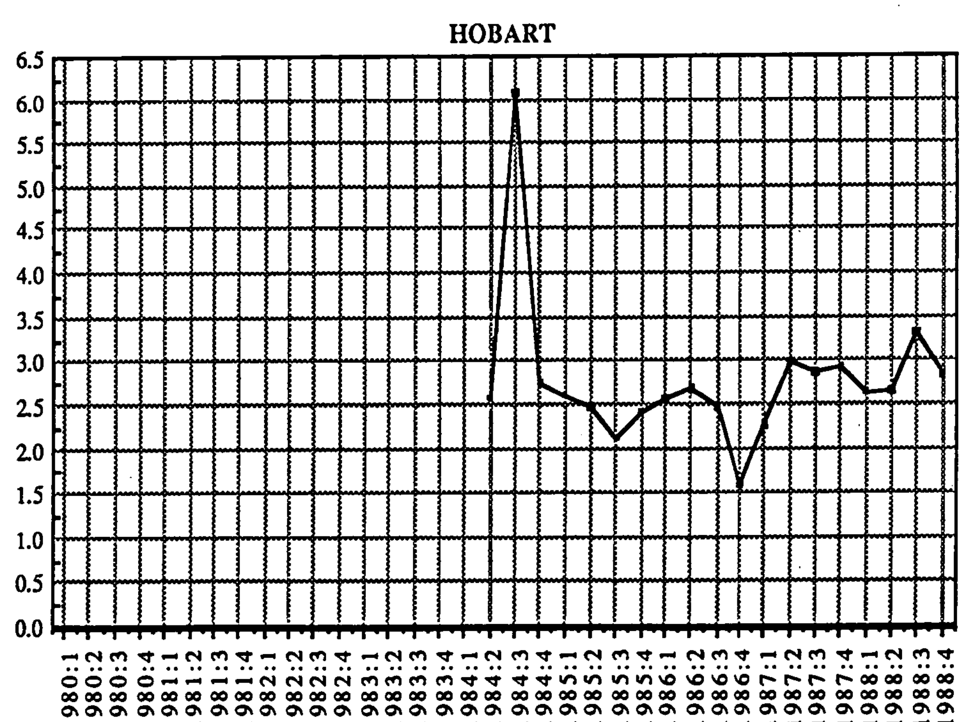


FIGURE 4.1 continued ...





a. The sample period for Hobart begins in 1984:2

Table 4.2 shows the results of the instrumental variables estimation of the model given in (4.7). The columns headed (1) and (2) indicate the different specifications using the two alternative measures of credit availability and of the initial mortgage payment.

Table 4.2
Results of Instrumental Variables Estimation of Equation(4.7)

Variable	Sydney (1)	Sydney (2)	Melbourne (1)	Melbourne (2)
H	-0.033	-0.013	0.046	0.030
	(0.024)	(0.025)	(0.031)	(0.026)
	[-1.386]	[-0.505]	[1.494]	[1.168]
y	13.196*	2.243	6.040	7.314
	(6.122)	(6.519)	(7.077)	(5.707)
	[2.156]	[0.344]	[0.854]	[1.282]
hh	76561*	79090*	12749	8369.8
	(9811.2)	(8493.6)	(9578.4)	(7815.2)
	[7.803]	[9.312]	[1.331]	[1.071]
CA_1	-0.039	–	0.002	–
	(0.059)		(0.059)	
	[-0.656]		[0.041]	
CA_2	–	-0.417*	–	-0.328*
		(0.154)		(0.127)
		[-2.716]		[-2.575]
MP	6.140	–	5.788	–
	(5.823)		(5.257)	
	[1.054]		[1.101]	
AQLR	–	-0.123	–	8.040*
		(4.663)		(4.140)
		[-0.026]		[1.942]
DN	6655*	8004*	13133*	13256*
	(2800)	(2350)	(2681.5)	(2118.6)
	[2.377]	[3.406]	[4.898]	[6.257]
UC	-250.440	1152.600	2910.300	3375.400*
	(1133.4)	(1172.3)	(1974.5)	(1593.4)
	[-0.221]	[0.983]	[1.474]	[2.118]
$\Delta \log Ph_{t+1}$	151.980	151.040*	-311.540	-238.010*
	(117.72)	(86.732)	(186.84)	(136.55)
	[1.291]	[1.741]	[-1.667]	[-1.743]
constant	-0.122×10^7*	-0.125×10^7*	-0.343×10^6*	-0.261×10^6*
	(0.191×10^6)	(0.172×10^6)	(0.173×10^6)	(0.140×10^6)
	[-6.377]	[-7.268]	[-1.983]	[-1.863]
R^2	0.883	0.906	0.878	0.920
$\bar{R}^2$	0.844	0.874	0.842	0.896
DW	1.927	2.016	2.144	2.045
Rho	0.015	-0.021	-0.085	-0.036

Table 4.2 continued ...

Variable	Brisbane		Adelaide	
	(1)	(2)	(1)	(2)
H	-0.035	0.007	0.517*	0.378
	(0.073)	(0.082)	(0.270)	(0.474)
	[-0.483]	[0.087]	[1.914]	[0.798]
y	15.685	15.981*	-0.0004	-0.0003
	(9.878)	(8.925)	(0.0002)	(0.0003)
	[1.588]	[1.791]	[-0.779]	[-0.751]
hh	40195*	33248	-36903*	-39747*
	(20297)	(20806)	(8226.6)	(10309)
	[1.980]	[1.598]	[-4.486]	[-3.855]
CA_1	-0.043	--	-0.315*	--
	(0.158)		(0.188)	
	[-0.274]		[-1.675]	
CA_2	--	-0.345	--	-0.881
		(0.379)		(0.533)
		[-0.913]		[-1.653]
MP	2.182	--	9.618*	--
	(17.601)		(3.954)	
	[0.124]		[2.433]	
AQLR	--	-5.780	--	11.156
		(17.554)		(10.990)
		[-0.329]		[1.015]
DN	3331	2202	8894*	11516*
	(5416)	(6025)	(2364)	(3541)
	[0.615]	[0.366]	[3.762]	[3.252]
UC'	975.450	495.870	5539.100*	4077.400*
	(1719.2)	(1566.7)	(1749.7)	(2112.8)
	[0.567]	[0.317]	[3.166]	[1.930]
$\Delta logPh_{t+1}$	-571.890	-437.880	-267.180	-481.220
	(389.18)	(370.2)	(266.73)	(408.61)
	[-1.470]	[-1.183]	[-1.002]	[-1.178]
constant	-0.663×10^6*	-0.568×10^6*	0.353×10^6*	0.434×10^6*
	(0.317×10^6)	(0.329×10^6)	(0.161×10^6)	(0.251×10^6)
	[-2.093]	[-1.726]	[2.199]	[-1.728]
R^2	0.251	0.399	0.837	0.754
$\bar{R}^2$	0.011	0.206	0.786	0.675
DW	1.967	1.833	1.902	1.994
Rho	0.007	0.078	0.029	-0.017

Table 4.2 continued ...

Variable	Perth (1)	Perth (2)	Hobart (1)	Hobart (2)
H	-0.129*	-0.136*	1.402*	1.089
	(0.060)	(0.052)	(0.622)	(0.848)
	[-2.146]	[-2.582]	[2.256]	[1.283]
y	-1.204	1.273	15.158	31.592
	(1.988)	(2.177)	(23.494)	(30.634)
	[-0.606]	[0.585]	[0.645]	[1.031]
hh	1153.200	3191.600	7231.100	30492
	(3633.8)	(3152.6)	(24506)	(35845)
	[0.317]	[1.012]	[0.295]	[0.851]
CA_1	0.027	--	-0.029	--
	(0.085)		(0.050)	
	[0.321]		[-0.587]	
CA_2	--	-0.212*	--	0.010
		(0.113)		(0.277)
		[-1.879]		[0.034]
MP	12.726*	--	-26.813*	--
	(7.291)		(11.003)	
	[1.745]		[-2.437]	
AQLR	--	12.167*	--	-10.458
		(5.626)		(16.511)
		[2.162]		[-0.633]
DN	-663.510	-60.182	-13784*	6806
	(1723.3)	(1446.6)	(5463.8)	(11639)
	[-0.385]	[-0.042]	[-2.523]	[-0.585]
UC'	-1173.000*	-1116.400*	-90.336	-77.260
	(638.230)	(608.690)	(845.89)	(1074.5)
	[-1.838]	[-1.834]	[-0.107]	[-0.072]
$\Delta logPh_{t+1}$	31.865	30.324	214.740	123.64
	(72.146)	(67.527)	(130.340)	(292.370)
	[0.442]	[0.449]	[1.648]	[0.423]
constant	71958	26755	-0.216×10^6	-0.667×10^6
	(84634)	(71863)	(0.558×10^6)	(0.816×10^6)
	[0.850]	[0.372]	[-0.386]	[-0.818]
R^2	0.757	0.788	0.844	0.687
$\bar{R}^2$	0.679	0.721	0.706	0.409
DW	2.066	1.948	2.700	2.025
Rho	-0.074	-0.059	-0.037	-0.028

Table 4.2 continued ...

Variable	AUSTRALIA (1)	(2)
H	-0.031 (0.024) [-1.260]	-0.039 (0.027) [-1.444]
y	35.429 (22.476) [1.576]	30.762 (20.557) [1.496]
hh	110050 (64456) [1.707]	104950* (54689) [1.919]
CA_1	-0.001 (0.005) [-0.316]	--
CA_2	--	-0.002 (0.012) [-0.191]
MP	19.914 (18.949) [1.051]	--
AQLR	--	21.785 (15.334) [1.421]
DN	6688 (8961) [0.746]	8375 (8270) [1.013]
UC'	-539.680 (2165.1) [-0.249]	104.580 (2105.8) [0.050]
$\Delta logPh_{t+1}$	-666.860 (650.790) [-1.023]	-602.580 (574.160) [-1.050]
constant	-0.180×10^7 (0.105×10^7) [-1.717]	-0.168×10^7* (0.888×10^6) [-1.890]
R^2	0.673	0.715
$\bar{R}^2$	0.485	0.552
DW	2.370	2.226
Rho	-0.227	-0.164

Note: Dependent variable in each case is rph = the real median price of houses; standard errors appear in parentheses and t statistics appear in square brackets; * indicates significance at 0.05; the units of measurement of the variables give rise to their extreme relative magnitudes.

In light of the limitation in measuring the nominal mortgage interest rate, an attempt was made to test the hypothesis that a lack of variability in the mortgage interest rate (because Savings Banks were subject to a 13.5 percent ceiling until April 1986) influenced the signs and relative magnitudes of the estimated coefficients, particularly with respect to the variables MP, DN and UC'.

The model was re-estimated using only the nominal mortgage interest rate charged by Permanent Building Societies in each State to calculate the data series on DN, MP and UC'. This may be justified on the basis that the nominal mortgage interest rate charged by Permanent Building Societies in each State is likely to be a suitable proxy for the nominal mortgage interest rate that *would be charged* by Savings Banks if they too had been unregulated. The results of this re-estimation are presented in Appendix D where the figures in **bold type** in the columns headed (1)b and (2)b are those for which only the Building Society interest rate was used. There was very little change in the signs or relative significance of the parameter estimates. It appears, therefore, that neither the inconsistency of the results across specifications (as discussed in Chapter 5), nor the unexpected coefficient signs can be attributed to this limitation.

Using the first-stage parameter estimates presented in Table 4.2 the estimated coefficients and associated elasticities of the inverse demand function may now be identified.[10]

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[10] Note that the parameter estimates reported in Table 4.1 are based on units of measurment of the dependent variable rph in $'000. Hence, in the calculations to identify the individual coefficients of the inverse demand function, presented in Table 4.3, it was necessary to rescale the β's to measure

4.5 ESTIMATED COEFFICIENTS AND ELASTICITIES

In Table 4.3, the individual coefficients of the inverse demand function are presented. These have been identified using the second-stage parameter estimates presented in Table 4.2. For example, the derivation of the model used for estimation [Section 4.2] , implies that the direct estimation results of the variable coefficients constitute elements of the product $j/(1+\alpha_1\beta_1)$ necessitating identification of the elements of vector j for each specification [see equation (4.7)]. The first-stage results, obtained by estimating the supply-side of the model (presented in Table 4.1), facilitate the full identification of the demand-side coefficients.

Table 4.3

Estimated Coefficients of the Inverse Demand Function

Parameter Estimate	Sydney (1)	Sydney (2)	Melbourne (1)	Melbourne (2)
α_1 =	-0.033	-0.013	0.486	0.315
α_2 =	13.173*	2.241	6.438	7.626
α_3 =	76426*	79035*	12136	8727
α_4 =	-0.039	-0.417*	0.002	-0.342*
α_5 =	6.129	-0.123	6.169	8.383*
α_6 =	6643*	7998*	13998*	13821*
α_7 =	-250.886	1151.839	3102.407	3519.658*
α_8 =	151.713	150.936*	-332.062	-248.171*
constant =	-0.122×10^7*	-0.125×10^7*	-0.341×10^6*	-0.260×10^6*

* indicates significance at 0.05.

the real asset price of housing (dependent variable, rph) in dollars.

Table 4.3 continued ...

Parameter Estimate	Brisbane (1)	Brisbane (2)	Adelaide (1)	Adelaide (2)
α_1 =	-0.035	0.007	0.527*	0.383
α_2 =	15.616	15.995*	-0.0004	-0.0003
α_3 =	40017*	33277	-37618*	-40307*
α_4 =	-0.043	-0.345	-0.321*	-0.893
α_5 =	2.172	-5.785	9.804*	11.313
α_6 =	3316	2204	9066*	11678*
α_7 =	971.146	496.309	5646*	4135*
α_8 =	-569.365	-438.268	-272.361	-488.006
constant =	-0.660×10^6*	-0.568×10^6*	0.360×10^6*	0.440×10^6*

Parameter Estimate	Perth (1)	Perth (2)	Hobart (1)	Hobart (2)
α_1 =	-0.128*	-0.135*	1.413*	1.096
α_2 =	-1.198	1.266	15.276	31.783
α_3 =	1147	3175	7288	30676
α_4 =	0.027	-0.211*	-0.029	0.010
α_5 =	12.662*	12.102*	-27.022*	-10.521
α_6 =	-660.172	-59.863	-13891*	-6847
α_7 =	-1167*	-1110*	-91.040	-76.727
α_8 =	31.704	30.163	216.414	124.388
constant =	72293	26613	-0.217×10^6	-0.671×10^6

Parameter Estimate	AUSTRALIA (1)	AUSTRALIA (2)
α_1 =	-0.031	-0.038
α_2 =	34.949	30.239
α_3 =	108559	103167*
α_4 =	-0.001	-0.002
α_5 =	19.644	21.415
α_6 =	6597	8233
α_7 =	-532.367	102.804
α_8 =	-657.824	-592.344
constant =	-0.177×10^7	-0.165×10^7*

In Table 4.4 the estimated elasticities of real house prices with respect to each of the independent variables in the model are presented. These elasticities have been calculated at the variable sample means and, given the lack of a marked variation of the results between the two specifications, are given for specification (1) only.

Similarly, in Table 4.5 the price elasticities of supply are presented. These represent the responsiveness of new housing production to a proportionate change in the real price of units of housing stock.

Table 4.4

Demand-Side Elasticities Evaluated at Means[a]

Variable	Sydney	Melbourne	Brisbane	Adelaide	Perth	Hobart	AUSTRALIA
H	-0.83	1.17	-0.67	**5.27**	**-1.45**	**5.24**	-2.82
y	**0.77**	0.49	1.43	-0.67	-0.13	1.36	2.57
hh	**17.75**	4.08	**15.56**	**-13.39**	0.52	2.89	32.50
CA	-0.01	0.00	-0.01	**-0.02**	0.00	0.00	0.00
MP	0.13	0.15	0.06	**0.28**	**0.39**	**-0.85**	0.55
DN	**0.64**	1.74	0.54	**1.34**	-0.12	**-2.27**	0.80
UC'	-0.01	0.13	0.05	**0.28**	**-0.07**	-0.01	-0.03
$\Delta logPh_{t+1}$	0.00	-0.01	0.00	0.00	0.00	0.01	-0.02

a Elasticities printed in bold type are those associated with statistically significant coefficient estimates (two-tailed test at the 5% level of significance).

Table 4.5

Supply-Side Elasticities Evaluated at Means [a]

City	Price Elasticity of Supply
Sydney	0.38
Melbourne	0.88
Brisbane	0.69
Adelaide	0.68
Perth	0.38
Hobart	0.24
AUSTRALIA	0.75

a Each of these elasticites is associated with a statistically significant coefficient estimate as reported in Table 4.1.

These results are discussed in Chapter 5.

CHAPTER FIVE: *Results*

5.1 INTRODUCTION

In this chapter the individual coefficient estimates of the inverse demand function and the estimated elasticities are discussed, and possible reasons for the inconsistencies in the results are addressed.

Anticipating the results presented below, there appears to be little consistency in the estimates across the different cities. A notable feature is the variation in the performance of the variables that are of particular interest in the present study; MP, DN and UC. The results neither corroborate the hypotheses postulated nor do they provide conclusive evidence in support or refutation of the economic priors outlined in the preceeding chapters.

5.2 ANALYSIS OF RESULTS

Some care should be taken in interpreting the individual coefficient estimates, particularly since the units of measurement of the variables imply a wide range of coefficient magnitudes which are poor indicators of relative impacts. A more fruitful line of inquiry is to examine the implied elasticities. This is undertaken in Section 5.2.2. Simple examination of the coefficient estimates does, however, yield some useful observations.

5.2.1 Coefficient Estimates

The specifications yield estimated coefficients which, in many cases, do not agree with expectations. In seven of the fourteen reported cases the coefficient α_1 was negative (statistically significant only in Perth), demonstrating the expected effect of the existing stock of housing on the real price of housing. In Adelaide (1) and Hobart (1), however, the estimates indicate a significant positive effect. The income effect was positive in all cases, except for a non-significant negative income effect in Adelaide (1) and (2). The coefficient α_3 on the demographic variable was positive in all cases (significant in four) except Adelaide (1) and (2) (where it was, surprisingly, significantly negative). The measures of credit availability performed poorly with the coefficient α_4 on CA_1 positive, as expected, in only two cases (Melbourne (1) and Perth (1)), neither statistically significant, and the coefficient α_4 on CA_2 positive, as expected, in only one case (Hobart (1)), and not statistically significant. Indeed, there was one case in which the coefficient on CA_1 was negative and statistically significant and three cases in which the coefficient on CA_2 was negative and statistically significant (Adelaide (1) and Sydney (2), Melbourne (2) and Perth (2) respectively).

The notable failing of the models, in the context of this study, was the variation in the performance of the variables MP, AQLR, DN and UC'. The coefficient α_5 on MP was negative, as expected, in Hobart (1) only (and statistically significant) with there being two cases (Adelaide (1) and Perth (1)) in which the coefficient was positive and statistically significant. The coefficient α_5 on AQLR was negative in three cases (none statistically significant) and was positive and statistically significant in two cases (Melbourne (2) and Perth (2)). The coefficient α_6 on DN was, in contrast to expectations, positive in all cases (significant in six of these) except for Perth and Hobart (significant for Hobart (1) only) and the coefficient α_7 on UC' was negative, as expected, in six cases (Perth(1) and (2) being significant) and positive and significant in three cases (Melbourne (2) and Adelaide (1) and (2)).

Of particular interest is the sign of the coefficient of the price expectations variable, $\Delta \log Ph_{t+1}$. Agents in this model have been assumed to make rational forecasts of future housing asset prices and these forecasts determine the current asset price of housing. As outlined in Section 2.2.2, if agents expect rising asset prices and capital gains, then they should be content to hold their housing asset, even in the face of an increase in the rental cost of housing. In terms of the coefficient signs, α_8 is expected to be positive, implying that rational expectations of real house price inflation would fuel housing demand. Further, if rational expectations do account for movements in house prices, their impact should be significant enough to offset any dampening effect on demand experienced, *ceteris paribus*, through increases in the exogenous user-cost of housing. The results, however, indicate only six cases in which α_8 is positive and it is statistically significant in only one of these (Sydney(2)). Since both UC' and $\Delta \log Ph_{t+1}$ are measured as percentages, their individual coefficient estimates may be compared in absolute magnitude. In making this comparison, it is clear that in only two cases is the price expectation effect large enough to offset the user-cost effect (Hobart (1)&(2)).

5.2.2 Elasticities

The estimated elasticities provide some guide to the responsiveness of real house prices to changes in the independent variables included in the model. Whilst the direction of response is already implied by the sign of the estimated coefficient, the relative impact of the responses, implied by the elasticities, is of interest.

Examining Table 4.4 indicates that, in the case of Sydney, Melbourne, Brisbane and Australia in aggregate, the strongest upward pressure on house prices in the sample period was exerted by the demographic variable, hh. Further, except in the case of Melbourne, the strongest downward pressure was exerted by the stock of housing. In contrast, a very large negative elasticity was estimated for Adelaide with respect to the demographic variable. This was partly offset by a very large positive elasticity with respect to the stock of housing.

Income exerted a fairly strong upward pressure in all cases except Adelaide and Perth. Due to the definition of the dependent variable, it is difficult to compare these elasticity magnitudes with those of previous studies. A comparable income elasticity of housing demand can be derived, however, by inverting the percentage change in real house prices brought about by a percentage change in the real housing stock and multiplying this by the percentage change in real house prices brought about by a percentage change in income. For the cases in which this can be considered legitimate, the derivation yields income elasticities of; 0.93 for Sydney, 2.13 for Brisbane and 0.91 for Australia. These are very different to the values of 1.36, 0.19 and 0.50 respectively, estimated by Selvanathan (1988) and are also at odds with Yates' (1981b) low estimate of 0.122 for Australia as a whole.

The responsiveness of real house prices to credit availability is negligable in all cases except Adelaide, and varies in direction. This lends some support to De Rosa's (1978) and Meltzer's (1978) research, which failed to find any impact of credit availability. [1]

The elasticity of real house prices with respect to the initial mortgage payment is, in all but one case, positive and, in some cases, quite large. This is in direct contrast to the effect postulated as the 'tilt effect'. The largest influence, however, was in the case of

[1] De Rosa's (1978) approach to assessing the impact of credit availability on residential investment was to analyse mortgage rationing in terms of its impact on the household's balance sheet. He argued that, if an excess demand for mortgages was to dampen housing demand in any important way, the major part of the excess mortgage demand must be absorbed in the household balance sheet by an excess demand for houses, rather than other items in the balance sheet. If households are free to adjust the other items in their balance sheet, then it is reasonable to expect that credit rationing would not be manifested in a fall in the demand for housing.

Hobart, where the value of the elasticity is -0.85.

The quite large elasticity with respect to the measure of the effective mortgage duration is a puzzle, particularly since it is positive in five of the seven reported cases. This, again is in direct contrast to the influence postulated. Surprisingly, it appears to exert a stronger influence on prices than the initial mortgage payment. The very small elasticity with respect to the exogenous user-cost component and, indeed, with respect to the price expectations variable was also unexpected. The latter indicates that, within the present model, expectations of future real house prices do not exert a strong influence on real house prices, nor do they appear to play an important role in determining the current asset price of housing. This is in direct contrast to the hypothesis outlined in section 2.2.2 and implied by the assumption of rational expectations in the theoretical model.

These observations about the individual coefficient estimates and their associated elasticities simply report the findings. It remains to attempt to analyse the implications of the results and these observations in the context of the present study. In doing so, the interpretation is guarded, since the empirical analysis, owing to the variation in performance of the explanatory variables across the different cities, provides little conclusive evidence in support or refutation of the hypotheses of the study.

5.3 IMPLICATIONS OF RESULTS WITHIN PRESENT MODEL

In this section the discussion is limited to the estimated coefficients that were found to be statistically significant. The most regular results that emerge from estimation of the empirical model are:

(i) The estimated coefficients of the income and demographic variables were largely of expected sign and exerted a relatively strong influence on the behaviour of real house prices and the current demand for housing;

(ii) None of the estimated coefficients of the credit availability variable were of expected sign, nor do the results indicate a very strong influence of credit availability on the current demand for housing;

(iii) The coefficients on the initial mortgage payment variable and exogenous user-cost were generally not of expected sign yet in some cases were quite large; and

(iv) The strong positive influence of the effective mortgage duration variable (in all but one case) is a puzzle.

Table 5.1 contains a summary of these results.

Table 5.1

Summary of Statistically Significant Results

			Number of Cases in which Coefficient Statistically Significant and:		
Variable	Coefficient	Expected Sign	of Expected Sign	Not of Expected Sign	TOTAL
H	α_1	<0	2	2	4
y	α_2	>0	2	-	2
hh	α_3	>0	4	2	6
CA	α_4	>0	-	4	4
MP	α_5	<0	1	4	5
DN	α_6	<0	1	6	7
UC	α_7	<0	2	3	5
$\Delta \log Ph_{t+1}$	α_8	>0	1	1	2

Empirical estimation of the theoretical model provides little conclusive evidence to enable the hypotheses of the present study to be either rejected or not rejected.

Specifically, the discussion of the effects of inflation on the demand for owner-occupied housing and the structure of the theoretical model implied the following hypotheses:

I That, ceteris paribus, inflation will tend to reduce the current demand for housing (and thus current house prices) through the characteristics of the mortgage instrument. (Channel One)

II That, ceteris paribus, inflation will tend to increase the current demand for housing (and thus current house prices) by reducing the user-cost of homeownership. (Channel Two)

Under the maintained assumption that agents form expectations rationally, the resolution of the two effects hypothesised in I and II will imply:

Outcome (a): a net reduction in the current demand for housing in response to inflation if channel one dominates channel two (see Section 3.4.1). House prices and the stock of housing units would therefore tend to decrease in response to an increase in inflation, *ceteris paribus.*; and

Outcome (b): a net increase in the current demand for owner-occupied housing in response to inflation if channel two dominates channel one (see Section 3.4.2). House

> prices and the stock of housing units would therefore tend to increase in response to an increase in inflation, *ceteris paribus.*

Prima facie, the results presented above suggest that the characteristics of the mortgage instrument dominate the influence of the user-cost of home ownership on the current real asset price of, and the current demand for, owner-occupied housing. This may be interpreted as implying that channel one dominates channel two, but, except in the case of Hobart, not in the way hypothesised under Outcome (a). In fact, the signs of the estimated coefficients imply that the net effect of this outcome may be to increase the current demand for housing. That is, the results imply that Outcome (a) may instead bring about the dynamic effects described under Outcome (b). This is a consequence of the strong positive influence of the variable DN.

It would, however, be unwise to conclude anything about the relative impacts of the two inflationary channels from this, since none of the cases provided enough statistically significant estimates to justify any such conclusion. Whilst this is somewhat discouraging, it does not, in itself, provide a basis upon which to dismiss the theoretical framework.

5.4 LIMITATIONS OF THE ANALYSIS

The data limitations of the study, that were known ex ante , were discussed in Section 4.4. The empirical evidence is suggestive but incomplete and it remains to evaluate the study in the light of technical inadequacies and possible conflicting theory.

5.4.1 Inadequacies of the Modelling Technique

The theoretical framework employed in this study has drawn on the models of several authors. While the essential features of these models have been retained, the way in which they have been combined is novel, and may be subject to criticism.

Each of the variables posited to capture the effects of inflation on the current demand for housing was developed on the basis of economic theory. The way in which they are incorporated together in the inverse demand function, however, is largely ad hoc. A broader household consumption-portfolio model may have been more revealing.

Since the question of tenure choice has not been addressed, the effect of the relative price of rental and owner-occupied housing has been overlooked. Given that the focus of the study has been upon the effect of inflation on the demand for housing as an asset (which provides a service flow over time) this is not considered to be a severe limitation. Rather, it may serve as a useful extension to the asset market model developed.

Application of the same model specification to each State Capital city fails to allow for the possibility of any inter-city differences. A full inter-regional economic analysis was beyond the scope of the present study, but it may be that the failure to incorporate specific regional characteristics was in part responsible for the inconsistency of the results across the different cases.

Finally, the way in which the influence of credit availability has been examined in the present study may be open to question. Fair and Jaffee (1972) have argued that a rigorous examination of the impact of credit availability requires the specification and estimation of a disequilibrium model. The equilibrium model specified in the present study may, therefore, restrict possibilities for examining the impact of credit rationing.

5.4.2 Inadequacies in Data Generation and Use

The necessary use of time series data in the application of the rational expectations hypothesis proved to be a serious limitation to the development of the empirical model. Perhaps the most severe limitation to the study in this context, however, was the need to generate series for many of the important variables.

The precise interpretation of the two variables created to measure credit availability is uncertain and, in relation to the first, Hendershott (1980) has argued that:

> "This variable ignores the impact of inflation on the purchasing power of the existing stock of deposits, deposits that are constantly being used to finance houses, that are rolling over at higher prices." [1980, p.412]

Further, neither measure takes account of the increase in mortgage financing that has been undertaken by non-traditional lenders, for example, credit unions.

The series generated for the initial mortgage payment was based on the average size of a loan made in each State in each quarter. The initial mortgage payment on a household's desired real value of a house in relation to that household's real disposable income would clearly capture the impact of the tilt problem and the non-price rationing of mortgage finance much better. In the absence of broad-based survey information about household and lender behaviour, however, the desired real value of a house is unknown. Using the average value of a loan to proxy the desired real value of a house to some extent accommodates the mortgage payment constraint in the sense that it is the value of the loan approval rather than the value of the loan applied for. It takes no account of the value of the house for which the loan was approved and, in turn, gives no information about the initial loan-to-value ratio. This, in addition to the difficulty in obtaining valid mortgage interest rate data (see Section 4.4), renders the calculated series for MP and DN open to criticism and may be partially responsible for the puzzling results.

Specification of the user-cost series was also a difficult task, since generation of a series on the unobservable inflationary expectations for each State Capital city was required. The use of optimal forecasting techniques for this purpose was a necessary simplification but may be deficient.

As already noted, the use of the median sale price of an established house in each State Capital city to represent the asset price of housing is imperfect. In particular, no adjustment is made for the quality of housing units. In the US studies data on quality-adjusted new house prices was utilised but no such data was available for Australia.

For consistency, both the price and quantity of housing stock should ideally be measured in homogeneous units. On the supply-side, the number of dwelling commencements, rather than their value, was utilised in attempt to partially overcome the inconsistency of using the price of established houses on the demand-side.

The reservations about the data series utilised for income and demographic characteristics were addressed in Section 4.4.

5.4.3 Alternative Theoretical Rationale

Sound methodology requires that the possibility of conflicting theory be acknowledged. However, it is difficult to offer an alternative theoretical rationale which would predict the coefficient signs obtained in the present study.

Some possible reasons for the negative impact of credit availability have already been given but the frequently positive impact of MP, DN and UC' remains a puzzle. Although the results yielded by the empirical model may cast some doubt on the approach, it is likely that the scarcity of suitable data and the construction of some series are the most severe limitations to the analysis.

CHAPTER SIX:

Conclusions and Options for Future Research

In this study, a dynamic model of the housing market was developed and utilised in an attempt to analyse the effect of inflation on the current demand for housing in Australia. The theoretical model developed was a partial equilibrium, asset market model, in which housing was considered as an investment good that supplied a flow of housing services over time. Expectations of future housing asset prices were assumed to be formed rationally and to therefore determine the current asset price of housing.

Inflation was postulated to affect current housing demand decisions through two channels. First, through the institutional features of the mortgage market and second, through its influence on the user-cost of home-ownership. A brief and simple examination of the evidence of a Fisher effect in the determination of Australian nominal interest rates served as a useful extension to the analysis.

Empirical investigation of the model necessitated the use of McCallum's (1976) instrumental variables technique, which provides consistent estimates of relationships involving rational expectations variables. The scarcity of data relating to the Australian housing market was a significant constraint to the empirical analysis and the results obtained were only of consequential significance. Indeed, a notable failing of the empirical side of the study was the variation in the performance of the variables of particular interest; MP, DN and UC, and the inconsistency of the associated coefficient estimates.

Since the results provided little conclusive evidence in support or refutation of the stated hypotheses, little inference could be made about the likely path of house prices or the size of the stock of housing units in a changed inflationary environment. Therefore, the policy implications of the effects postulated could not be assessed. Had the results been of greater quantitative significance, they could have been employed usefully as the basis for a number of simulation experiments. For example, the estimated coefficients of the inverse demand function could have been used to compute the dynamic impacts of changes in inflationary expectations on the Australian housing market.

It would be unwise to use the poor results as grounds for the dismissal of the modelling technique or methodology of the study. With the benefit of hindsight, it appears that the inconsistencies are a likely result of inadequacies in data generation and use.

Recent experience of a significant downturn in housing activity, in the presence of high nominal mortgage interest rates, is suggestive of a significant influence of the cost of housing finance on the demand for housing, although the extent to which the increased nominal rates are evidence of a Fisherian adjustment process is not clear. As new data come to hand, post-deregulation, further empirical investigation of the theoretical framework developed in this study may prove more fruitful. Future research efforts may be directed better towards developing a sound and extensive data set for empirical analysis rather than towards refining the theoretical analysis.

Although the explicit empirical objective of the research was not met, the implicit theoretical objectives were. The research was also undertaken in a sound and systemmatic way. By looking at two channels through which inflation was posited to affect current housing demand decisions, and drawing together two streams of literature that have emerged in this area of research, a simple, but thorough, theoretical framework was developed. This framework, and the economic theory upon which it was based, gives some insight into the possible effects of inflation in the Australian housing market. The hypotheses implied by the analysis were, in principle, testable but, until adequate information is available upon which model estimation can be based, the relative merits of the theoretical rationale cannot be assessed fairly. It is a topic worthy of further investigation.

APPENDIX A

Consider a homebuyer who purchases a 1985/86 median priced Australian house at $78,000, pays a 10 percent cash deposit of $7,800 and obtains a T=20 year SFPM for the remaining $70,200 which bears a real rate of interest of 6 percent per annum, compounded quarterly. If Fisherian interest rates are assumed, so that the nominal interest rate, i, is the sum of the real interest rate, r, and an allowance for the fully anticipated rate of inflation, π^e, then when $\pi^e = 0\%$, $r = 6\% = i$ the quarterly mortgage payments the homebuyer will be required to pay to fully amortise the $70,200 over 20 years are calculated as:

$$A = R \,.\, A_{n,i/m} \qquad \text{or} \qquad R = A/A_{n,i/m}$$

where
- R = quarterly payment;
- n = number of compounding periods = T.m where m is the frequency of compounding each year (i.e. quarterly compounding implies m=4);
- i/m = nominal rate of interest per compounding period;
- A = the present value of an ordinary annuity; and
- $A_{n,i/m}$ = the present value of $1 per period for n periods compounded at the rate i/m per period.

Hence, $R = \$70{,}200/A_{80,0.015} = \$1{,}512.69$ per quarter.

If the nominal interest rate increased to just over 16 percent in the light of anticipated inflation of 9.5 percent then the quarterly mortgage payments for the homebuyer would increase to:

$$R = \$70{,}200/A_{80,0.0402} = \$2{,}946.40 \text{ per quarter.}$$

[**Note**: the nominal interest rate is here calculated on the basis that: $(1+i)=(1+r)(1+\pi^e)$]

In the absence of inflation, the nominal and real quarterly payments would be constant and equal at $1,512.69 per quarter. As anticipated inflation increases the nominal interest rate, however, the time profile of the stream of *real* quarterly payments changes, as shown in Table A.1, where the second column headed "Real Quarterly Payment" shows the constant (year 0) dollar value of the nominal quarterly payment calculated as:

$$\text{Real Payment} = \text{Nominal Payment } (1+\pi^e)^{-t}$$

where t is the number of years of the loan that have elapsed.

TABLE A.1

Year	Nominal Quarterly Payment	Real Quarterly Payment	Real Annual Payment
π^e=0%, r=6%, i=6%			
0	1,512.69	1,512.69	6,050.76
5	1,512.69	1,512.69	6,050.76
10	1,512.69	1,512.69	6,050.76
15	1,512.69	1,512.69	6,050.76
20	1,512.69	1,512.69	6,050.76
π^e=7%, r=6%, i=13.5%			
0	2,536.20	2,536.20	10,144.80
5	2,536.20	1,808.28	7,233.12
10	2,536.20	1,289.28	5,157.12
15	2,536.20	1,009.24	3,676.96
20	2,536.20	655.40	2,621.60
π^e=9.5%, r=6%, i=16%			
0	2,946.40	2,946.40	11,785.60
5	2,946.40	1,871.63	7,486.54
10	2,946.40	1,188.91	4,755.66
15	2,946.40	755.23	3,020.92
20	2,946.40	479.74	1,918.97

APPENDIX B

The following example serves to illustrate the type of constrained utility maximisation problem which underlies the derivation of the Marshallian demand curves discussed in Section 2.2.1 of the text. The problem presented here is very similar to that which formed the basis of the analysis in Male (1988).

Suppose the specific form of the household utility function is:

$$\boxed{V = \sum_{t=1}^{N} \{ (1+\tau)^{-1}\}^{t-1}. (-C_t^{-\rho} - \gamma H^{-\rho});} \quad \rho > 0 \qquad \textbf{(B.1)}$$

which is the CES function used by Schwab (1982) and Alm and Follain (1984). ρ is the parameter representing the elasticity of marginal utility , $-(\rho + 1)$ is the elasticity of marginal utility with respect to C_t and γ is the parameter which relates the utility of housing to the utility of the composite non-housing good.

Collapsing the planning horizon into two periods (the first representing the current year and the second all subsequent years) and assuming the purchase of H units of housing stock is bond-financed at the beginning of the first period, the household's intertemporal budget constraint (abstracting from bequests) may be written:

$$Y_1 + b + Y_2/(1+i) + Ph_2^eH/(1+i) =$$

$$P_1C_1 + b + P_2^eC_2/(1+i) + bi/(1+i) + b/(1+i) \quad \textbf{(B.2)}$$

where Y_t = expected nominal income stream in period t;
b = bond issues at the beginning of period 1;
P_1 = price of non-housing goods in period 1;
P_2^e = price of non-housing goods expected to prevail in period 2;
Ph_2^e = purchase price per unit of housing stock expected to prevail in period 2; and
i = nominal interest rate.

The household is assumed to have no inherited wealth or initial debt and, to be out of debt at the end of the planning horizon, the household must redeem all outstanding bonds in the second period, having paid interest on them at the end of the first period. These debts are assumed to be cleared in the second period through the sale of the house.

Since households are generally restricted by lenders to borrowing less than 100 per cent of the purchase price of the home as a mortgage, the bond issues may be expressed as:

$$b = L.\ Ph_1H$$

where L = initial loan-to-value ratio (proportion of the house purchase which is bond-financed); and

Ph_1 = the purchase price per unit of housing stock in period 1.

Furthermore, since households are typically unable to borrow and lend at the same nominal interest rate, a differential borrowing rate, i_b, may be introduced to capture the cost of mortgage finance and i_o, the nominal discount rate, represents the opportunity cost of housing equity acquisition.

Incorporating these features into (B.2):

$$Y_1 + Y_2/(1+i_o) = P_1C_1 + P_2^eC_2/(1+i_o) + L\,Ph_1H\,i_b/(1+i_o)$$

$$+ (1-L)Ph_1H\,i_o/(1+i_o) + Ph_1H/(1+i_o) - Ph_2^eH/(1+i_o) \qquad \textbf{(B.3)}$$

where $(1-L)Ph_1Hi_o/(1+i_o)$, which is the downpayment on H, is financed out of current consumption expenditure because of the assumption that the household's initial net wealth is zero. Note that the difference between Ph_2^e and Ph_1 represents the nominal capital gains (or losses) that the household expects to accrue at point of sale.

The expected future prices may be rewritten as:

$$P_2^e = P_1[\,1 + \pi^e]\ ; \text{ and}$$

$$Ph_2^e = Ph_1[\,1 + \pi^e + \pi h^e]$$

where π^e is the expected rate of general price inflation and πh^e is the expected rate of real house price inflation (analagous to $Ph^\bullet/Ph$ in the text). Combining these expressions with the budget constraint in (B.3) yields:

$$Y_1 + Y_2/(1+i_o) = P_1C_1 + P_1[1+\pi^e]\, C_2/(1+i_o)$$
$$+ Ph_1H.[L\, i_b + (1-L)\, i_o - \pi^e - \pi h^e]\, /(1+i_o) \qquad \textbf{(B.4)}$$

The term $[Li_b + (1-L)i_o - \pi^e - \pi h^e]$ represents the user-cost of owner-occupied housing assuming, for simplicity of illustration, the absence of depreciation, maintainance, property taxes and miscellaneous expenses.

The marginal utilities derived from the utility function in (B.1) are:

$$\partial U/\partial C_1 = \rho\, C_1^{-(\rho+1)} = MU_{C1}$$
$$\partial U/\partial C_2 = \rho\,(1+\tau)^{-1}\, C_2^{-(\rho+1)} = MU_{C2}$$
$$\partial U/\partial H = \rho\,\gamma\,[1 + (1+\tau)^{-1}]\, H^{-(\rho+1)} = MU_H$$

Maximising (B.1) subject to the intertemporal budget constraint in (B.4), utilising the marginal utilities derived above, yields the following first-order conditions:

$$MU_{C1} - \lambda P_1 = 0 \qquad \textbf{(B.5)}$$
$$MU_{C2} - \lambda P_1[\,1 + \pi^e]\,(1+i_o)^{-1} = 0 \qquad \textbf{(B.6)}$$
$$MU_H - \lambda[Li_b + (1-L)i_o - \pi^e - \pi h^e]\,(1+i_o)^{-1} = 0 \qquad \textbf{(B.7)}$$
$$Y_1 + Y_2\,(1+i_o)^{-1} - P_1C_1 - P_1[1+\pi^e]\, C_2\,(1+i_o)^{-1}$$
$$- Ph_1H.[Li_b + (1-L)i_o - \pi^e - \pi h^e]\,(1+i_o)^{-1} = 0 \qquad \textbf{(B.8)}$$

where λ is the Lagrange multiplier associated with the budget constraint and C_1 , C_2 , H and λ are non-negative.

The first-order conditions in (B.5)-(B.8) may be solved simultaneously to yield the household's commodity demands of the general form:

$$C_1 = g_1 \{ W, P_1, P_2^e, Ph_1, UC\}$$

$$C_2 = g_2 \{ W, P_1, P_2^e, Ph_1, UC\}$$

$$H = f \{ W, P_1, P_2^e, Ph_1, UC\}$$

where W = total nominal lifetime wealth; and

UC = $[Li_b + (1\text{-}L)i_o - \pi^e - \pi h^e]$.

The housing demand function described in the text has other determinants, (i.e. hh, CA and M in equation (2.1)), and the user-cost measure includes, in equation (2.4), other terms (i.e. x , d and m). The problem outlined above could be extended to incorporate these other determinants and the solution procedure would be the same, albeit more cumbersome. Further, it should be noted that the explicit solutions implied by the first-order conditions depend on the choice of the explicit form of the household utility function (assumed, in the example above, to be a CES function).

APPENDIX C

In examining the effect of inflation on nominal interest rates in Australia, the first task is to obtain a proxy for the explanatory variable, namely inflationary expectations. In previous studies a variety of models of inflationary expectations have been used; from Feldstein and Summers' (1978) ARIMA(1,1,1), Poterba's (1984) rolling ARMA(1,1), Rosen, Rosen and Holtz-Eakin's (1984) ARIMA(1,1,0) to Goodwin's (1986) bivariate AR process. After some preliminary analysis of the Australian Consumer Price Index data, a first-order moving average process was selected. Since stationarity required first differencing the data, inflationary expectations were modelled as an ARIMA(0,1,1) process with the following results:

$$\Delta y_t = \underset{(0.0829)}{(\ 1 - 0.6956\ B\ )}\ \upsilon_t \qquad R^2 = 0.3543$$

where υ_t is a serially uncorrelated error term with $E(\upsilon_t)=0$ and $var\,\upsilon_t = \sigma_\upsilon{}^2$; Δy_t is a first-differenced series (i.e. Δ=1-B) on the quarterly rate of inflation in the Consumer Price index; and B is the 'backshift' or lag operator. The addition of a constant term did not improve the fit, whereas the t statistic associated with the θ_1 parameter estimate showed θ_1 to be statistically significantly different from zero.

By way of diagnostic checking, a quantitative analysis on the residuals generated by the model was carried out. The random error terms, υ_t, in the actual inflationary process are assumed to be normally distributed and independent of each other. Therefore, if the model is specified correctly, then the residuals, which are estimates of the unobservable error terms, should resemble a "white noise" process. A convenient test of this, developed by Box and Pierce (1970), is based on the Q statistic, referred to in some texts as the Portmanteau test statistic. The Q statistic is calculated as:

$$Q = n\ (r_1{}^2 + r_2{}^2 + r_3{}^2 + \ldots\ldots + r_k{}^2)$$

where the r's are the residual autocorrelations for displacement 1 .... k, and n is the number of sample observations. The Q statistic is a chi-square distributed variable with (k-p-q) degrees of freedom, where p is the number of autoregressive parameters (p=0 in this case) and q is the number of moving average parameters (q=1 in this case) in the model at hand. A statistical hypothesis test of model assumptions can be performed by comparing the observed value of Q with the appropriate critical values from a χ^2 table. The null hypothesis for this test is; H_0: all the residuals are white noise.

The printout from the TSP (Version 4.2) Box-Jenkins estimation procedure contains the calculated values of the Q statistic for the first k=20 autocorrelations of the residuals. For the ARIMA(0,1,1) model the null hypothesis cannot be rejected for all 20 autocorrelations at both the 90% and 95% levels of confidence i.e. the probability that the residuals are drawn from a white noise process is at least 95%. To determine if this was the "best" specification, many more ARIMA models were tested but it was not possible to obtain a lower chi-square statistic. The only model specification that resulted in a comparable Q statistic was the ARIMA(0,1,2) and, since the parameter estimate for θ_2 was not significantly different from zero, it is reasonable to conclude that the addition of a second moving average term was fruitless. Hence, the ARIMA(0,1,1) model was retained as the appropriate specification.

Once the appropriate model had been specified and tested, the next task was to calculate the forecasts of inflation that it implied. The optimal ARIMA forecasting procedure of Box and Jenkins (1970) was used for this purpose. Since the forecast inflation rate for time t was assumed to be based only on information available at that time, it was necessary to estimate a seperate Box Jenkins equation for each quarter. That is, for each quarter 1980:1 to 1989:1 an ARIMA(0,1,1) model was fitted to the data on quarterly inflation rates for the previous five years. As Rosen et. al. (1984) have suggested;

> "It is not obvious how far into the past the observations for each forecasting equation should go. One possible procedure is to choose some arbitrary length of time (say ten years) and assume that individuals use data only within that period to make their forecasts. Each year a new observation is added, and simultaneously the observation at the end of the sample is dropped." [p.408]

Rosen et.al. also discuss the alternative assumption that individuals employ new information as it becomes available over time, but continue to use the old information as well. Implying the number of observations upon which the forecasting equation is based grows each year. They found that the second assumption performed better but acknowledge that there is little theoretical basis for choosing between the two assumptions about how individuals process information. The first assumption is employed in this study since it was considered to be more applicable to a sample period which incorporates the high inflation period in the 1970's. This implicitly assumes that individuals have since recognised that those years were 'out of the ordinary'.

The relatively short five-year period was chosen to reflect the postulate that agents, who possess limited ability to process information, would be unlikely to 'look back' any more than twenty quarters when forming their expectations. This is, however, as stated above, quite an arbitrary choice, but convenient, in that it allows many more forecast observations to be made given that Australian quarterly inflation rate data has only been available since the very late 1960's. The same model specification was used each time in the absence of a theoretical basis to do otherwise.

Once estimated, the equation for each quarter was used to forecast the inflation rate for the next quarter. This follows the "rolling ARMA" technique used by Poterba and Feldstein and Summers to generate a time series of expected inflation rates. Some justifications for this procedure are discussed by Friedman (1979).

For example, the model:

$$\pi_t = \upsilon_t - \theta_1 \upsilon_{t-1}$$

is a moving average reaching back one period and;

$$\pi_t = (1 - 0.7106 \, B) \, \upsilon_t$$
$$(0.1129)$$

was fitted to quarterly observations on the CPI for the sample period 1975:2 to 1980:1 inclusive. This gave a one-period ahead forecast (i.e. for 1980:2) of 2.6 to 2 significant figures. The value 2.6 is the expectation, formed in the first quarter of 1980, of the quarterly inflation rate to prevail in the second quarter of 1980. That is, 2.6 is the 1980:1 observation on the expected inflation rate.

Table C.1 shows how these expectations performed by comparing the actual inflation rate that prevailed in period t with the forecast of inflation in period t that was formed in period (t-1).

TABLE C.1

Actual Inflation Rate in Quarter t Compared to what was Forecast for that Quarter in (t-1)

Quarter (t)	Actual	Forecast made in (t-1)	Error (Actual-Forecast)
1980:1	2.2	-	-
1980:2	2.8	2.6	0.2
1980:3	1.9	2.4	-0.5
1980:4	2.1	2.4	-0.3
1981:1	2.4	2.4	0.0
1981:2	2.2	0.4	1.8
1981:3	2.1	-0.6	2.7
1981:4	4.2	2.5	0.7
1982:1	1.7	2.4	-0.7
1982:2	2.4	2.4	0.0
1982:3	3.5	4.0	-0.5
1982:4	3.0	2.6	0.4
1983:1	2.2	2.5	-0.3
1983:2	2.1	2.4	-0.3
1983:3	1.6	2.3	-0.7
1983:4	2.4	2.4	0.0
1984:1	-0.4	-0.3	0.1
1984:2	0.2	0.7	-0.5

Table C.1 continued ...

1984:3	1.3	1.0	0.3
1984:4	1.4	1.2	0.2
1985:1	1.4	1.3	0.1
1985:2	2.4	1.7	0.7
1985:3	2.2	1.9	0.3
1985:4	2.0	1.9	0.1
1986:1	2.3	2.1	0.2
1986:2	1.7	1.9	-0.2
1986:3	2.6	2.2	0.4
1986:4	2.9	2.7	0.2
1987:1	2.0	2.3	-0.3
1987:2	1.5	1.8	-0.3
1987:3	1.7	1.8	-0.1
1987:4	1.7	1.8	-0.1
1988:1	1.8	1.8	0.0
1988:2	1.7	1.8	-0.1
1988:3	1.9	1.8	0.1
1988:4	2.1	1.8	0.3

Having generated a series for the unobservable explanatory variable the task remaining was to compare the evolution of nominal interest rates and the expected inflation rate. The regression results for the period 1980:1 to 1988:4 are summarised below [t statistics are in parenthesis]. These have been corrected for first-order autocorrelation of the residuals using the Cochrane-Orcutt procedure.

$$\underset{}{\text{MORTRATE}} = \underset{(7.687)}{2.885} + \underset{(0.064)}{0.001}\ \text{EXPINF} \qquad R^2=0.944\ \bar{R}^2=0.942,\ DW=1.239,\ Rho=0.976$$

$$\text{COMMBILL} = \underset{(13.124)}{3.425} - \underset{(-0.810)}{0.063}\ \text{EXPINF} \qquad R^2=0.525\ \bar{R}^2=0.510,\ DW=1.663,\ Rho=0.724$$

$$\text{LONGBOND} = \underset{(25.073)}{3.163} + \underset{(0.130)}{0.005}\ \text{EXPINF} \qquad R^2=0.595\ \bar{R}^2=0.582,\ DW=1.782,\ Rho=0.748$$

where MORTRATE = the predominant saving bank nominal mortgage interest rate on new housing loans to individuals for owner-occupation;

COMMBILL = the 90-day commercial bill nominal interest rate; and

LONGBOND = the nominal interest rate paid on 20-year bonds.

All data was taken from the Reserve Bank Monthly Bulletin (various issues). Where necessary, monthly data was converted to quarterly data and annual interest rates were converted to equivalent quarterly rates using the formula for the effective rate of interest. That is:

$$(1 + i/4)^4 = 1 + r$$

where r is the quoted average annual nominal rate of interest and i is the annual nominal rate of interest. These analytical results are in sharp contrast to those obtained by Poterba (1984, p.735):

$$\begin{array}{llllll} \text{MORTRATE} = & 4.14 + & 1.10\ \text{EXPINF} + & 0.65u_{-1} & & R^2=0.92 \\ & (0.64) & (0.15) & (0.23) & & DW=1.29 \end{array}$$

$$\begin{array}{llllll} \text{COMMBILL} = & 2.82 + & 0.82\ \text{EXPINF} + & 0.53u_{-1} & & R^2=0.59 \\ & (0.36) & (0.17) & (0.29) & & DW=1.40 \end{array}$$

Clearly, and especially in contrast to Poterba's results, these regression results do not support the proposition that nominal interest rates are explained by the expected inflation rate. The results point clearly to the significance of only the constant term, which indicates that there is litle variablity in nominal interest rates over the sample period. In relation to the objective of this analysis, no jointness in the evolution of nominal interest rates and inflation rates has been identified.

The results in the above three equations should not be alarming. Although other Australian researchers have found the estimated coefficient on their proxy variable for inflationary expectations to be significant, their estimated parameters were also very small in magnitude. For example, Volker's (1981) estimation of a number of alternative model specifications for determining the importance of inflationary expectations in the formulation of the 90-day commercial bill rate in Australia, yielded coefficients ranging from a low of 0.105 (s.e.=2.37) to a high of 0.209 (s.e.=4.36). "Probably the most striking aspect of the results", says Volker, "is the small extent to which inflationary expectations appear to be incorporated in the nominal rate." [Volker, 1981, p.251]

Although it may be possible to formulate specifications that would be able to better predict the behaviour of interest rates, by incorporating other explanatory variables, that would appear unnecessary for the task at hand. It remains that the above results indicate that there is no meaningful extent to which inflationary expectations (as determined by estimating a rolling ARIMA(0,1,1) process) appear to be incorporated into nominal rates for the period examined.

There may be some doubt as to the adequacy of the proxy variable used but, within the bounds of the present study, there is not a lot that can be do ne about this. Despite this, the evidence presented indicates that there are grounds for claiming that, for the period studied, the nominal mortgage interest rate in Australia is not responsive to changes in inflationary expectations.

APPENDIX D

When the empirical model was re-estimated using Permanent Building Society (PBS) nominal interest rates to serve as a proxy for the nominal mortgage interest rate that *would have been charged* by Savings Banks had they been unregulated for the entire sample period, the results presented in Table D.1 were obtained. The figures in **bold type**, in the columns headed (1)b and (2)b, are those for which only the PBS interest rate was used in calculating MP, DN and UC'. The figures in columns (1)a and (2)a are the original results for comparison. t statistics are given in square brackets.

Table D.1
Model Estimation Using PBS Nominal Interest Rates.[a]

Variable	Sydney				Melbourne			
	(1)a	(1)b	(2)a	(2)b	(1)a	(1)b	(2)a	(2)b
H	-0.033	**-0.059***	-0.013	**-0.004**	0.456	**0.056**	0.302	**0.040**
	[-1.386]	**[-2.367]**	[-0.505]	**[-0.139]**	[1.494]	**[1.527]**	[1.168]	**[1.595]**
y	13.196*	**13.898***	2.243	**-1.518**	6.040	**6.288**	7.314	**8.403**
	[2.156]	**[2.147]**	[0.344]	**[-0.207]**	[0.854]	**[0.863]**	[1.282]	**[1.524]**
h h	76561*	**69259***	79090*	**79168***	12749	**16877**	8370	**11722**
	[7.803]	**[7.228]**	[9.312]	**[8.210]**	[1.331]	**[1.620]**	[1.071]	**[1.527]**
CA_1	-0.039	**-0.044**	—	—	0.002	**0.006**	—	—
	[-0.656]	**[-0.742]**			[0.041]	**[0.096]**		
CA_2	—	—	-0.417*	**-0.470***	—	—	-0.328*	**-0.411**
			[-2.716]	**[-2.734]**			[-2.575]	**[-3.386]**
MP	6.140	**10.562***	—	—	5.788	**0.397**	—	—
	[1.054]	**[1.711]**			[1.101]	**[0.061]**		
AQLR	—	—	-0.123	**-3.137**	—	—	8.040*	**3.475**
			[-0.026]	**[-0.558]**			[1.942]	**[0.914]**
DN	6655*	**4469**	8004*	**8072***	13133*	**15134***	13256*	**15322***
	[2.377]	**[1.420]**	[3.406]	**[2.557]**	[4.898]	**[4.517]**	[6.257]	**[6.547]**
UC'	-250.4	**309.5**	1152.6	**1848.0**	2910.3	**3430.1***	3375.4*	**3686.7***
	[-0.221]	**[0.294]**	[0.983]	**[1.513]**	[1.474]	**[1.776]**	[2.118]	**[2.564]**
$\Delta logPh_{t+1}$								
	151.98	**155.75**	151.04*	**127.05**	-311.54	**-360.49***		
-238.01* **-245.08***			[1.291]	**[1.267]**	[1.741]	**[1.284]**	[-1.667]	**[-1.80]**
[-1.743] **[-1.917]**								
constant								
	$-0.12x10^{7}$*	$\mathbf{-0.11x10^{7}}$*	$-0.13x10^{7}$*	$\mathbf{-0.13x10^{7}}$*	$-0.34x10^{6}$*	$\mathbf{-0.43x10^{6}}$	$-0.261x10^{6}$*	$\mathbf{-0.34x10^{6}}$*
	[-6.377]	**[-5.682]**	[-7.268]	**[-6.259]**	[-1.983]	**[-2.177]**	[-1.863]	**[-2.394]**
R^2	0.883	**0.879**	0.906	**0.886**	0.878	**0.871**	0.920	**0.926**
$\bar{R}^2$	0.844	**0.839**	0.874	**0.847**	0.842	**0.833**	0.896	**0.905**
DW	1.927	**1.820**	2.016	**1.968**	2.144	**2.172**	2.045	**2.203**
Rho	0.015	**0.064**	-0.021	**-0.012**	-0.085	**-0.101**	-0.036	**-0.115**

Table D.1 continued ...

Variable	Brisbane				Adelaide			
	(1)a	(1)b	(2)a	(2)b	(1)a	(1)b	(2)a	(2)b
H	-0.035	-0.089	0.007	0.074	0.517*	0.181	0.378	0.594
	[-0.483]	[-1.188]	[0.087]	[0.937]	[1.914]	[0.409]	[0.798]	[1.175]
y	15.685	17.221*	15.981*	14.021*	-0.0004	-0.0002	-0.0003	-0.0004
	[1.588]	[1.792]	[1.791]	[1.881]	[-0.779]	[-0.656]	[-0.751]	[-1.049]
h h	40195*	40005*	33248	16008	-36903*	-39771*	-39747*	-46170*
	[1.980]	[2.042]	[1.598]	[0.837]	[-4.486]	[-3.635]	[-3.855]	[-3.553]
CA_1	-0.043	-0.083	—	—	-0.315*	-0.302	—	—
	[-0.274]	[-0.537]			[-1.675]	[1.445]		
CA_2	—	—	-0.345	-0.075	—	—	-0.881	-0.981
			[-0.913]	[-0.222]			[-1.653]	[-1.687]
MP	2.182	13.579	—	—	9.618*	19.171	—	—
	[0.124]	[0.769]			[2.433]	[1.582]		
AQLR	—	—	-5.780	-21.149	—	—	11.156	4.700
			[-0.329]	[-1.310]			[1.015]	[0.427]
DN	3330.6	999.9	2202.4	-5814.9	8893.6*	1016*	11516*	10290*
	[0.615]	[0.172]	[0.366]	[-0.876]	[3.762]	[3.236]	[3.252]	[2.640]
UC'	975.5	1196.4*	495.9	312.1	5539.1*	5142.5*	4077.4*	4813.0*
	[0.567]	[0.714]	[0.317]	[0.232]	[3.166]	[3.028]	[1.930]	[2.177]
$\Delta logPh_{t+1}$	-571.890	-566.670	-437.880	-120.050	-267.180	-281.730	-481.220	-513.780
	[-1.470]	[-1.478]	[-1.183]	[-0.329]	[-1.002]	[-0.827]	[-1.178]	[-1.108]
constant	-0.663×10^6*	-0.62×10^6*	-0.568×10^6*	-0.27×10^6	0.353×10^6*	0.52×10^6*	0.434×10^6*	0.47×10^6
	[-2.093]	[-2.036]	[-1.726]	[-0.860]	[2.199]	[2.646]	[-1.728]	[1.656]
R^2	0.251	0.267	0.399	0.591	0.837	0.798	0.754	0.714
$\bar{R}^2$	0.011	0.033	0.206	0.460	0.786	0.736	0.675	0.622
DW	1.967	1.956	1.833	1.426	1.902	2.008	1.994	2.011
Rho	0.007	0.011	0.078	0.276	0.029	-0.024	-0.017	-0.023

Table D.1 continued ...

Variable	Perth				Hobart			
	(1)a	(1)b	(2)a	(2)b	(1)a	(1)b	(2)a	(2)b
H	-0.129*	**-0.159***	-0.136*	**-0.134***	1.402*	**1.651***	1.089	**1.262**
	[-2.146]	**[-2.860]**	[-2.582]	**[-2.641]**	[2.256]	**[1.833]**	[1.283]	**[1.709]**
y	-1.204	**-1.161**	1.273	**2.282**	15.158	**23.619**	31.592	**40.047**
	[-0.606]	**[-0.562]**	[0.585]	**[0.843]**	[0.645]	**[0.692]**	[1.031]	**[1.436]**
h h	1153.2	**2171.1**	3191.6	**4169.9**	7231.1	**29642**	30492	**42502**
	[0.317]	**[0.698]**	[1.012]	**[1.232]**	[0.295]	**[0.688]**	[0.851]	**[1.338]**
CA_1	0.027	**0.029**	—	—	-0.029	**0.013**	—	—
	[0.321]	**[0.353]**			[-0.587]	**[0.135]**		
CA_2	—	—	-0.212*	**-0.259***	—	—	0.010	**0.091**
			[-1.879]	**[-1.923]**			[0.034]	**[0.458]**
MP	12.726*	**18.150***	—	—	-26.813*	**-24.183**	—	—
	[1.745]	**[2.226]**			[-2.437]	**[-1.693]**		
AQLR	—	—	12.167*	**12.347***	—	—	-10.458	**-4.873**
			[2.162]	**[2.077]**			[-0.633]	**[-0.579]**
DN	-663.510	**1379.5**	-60.182	**639.390**	-13784*	**-10445**	6805.6	**-3302.4**
	[-0.385]	**[0.914]**	[-0.042]	**[0.476]**	[-2.523]	**[-1.564]**	[-0.585]	**[-0.427]**
UC'	-1173.0*	**-895.690**	-1116.4*	**-1088.7**	-90.333	**357.070**	-77.260	**-56.505**
	[-1.838]	**[-1.374]**	[-1.834]	**[-1.653]**	[-0.107]	**[0.173]**	[-0.072]	**[-0.071]**
$\Delta \log Ph_{t+1}$	31.865	**30.751**	30.324	**13.067**	214.740	**283.420**	123.640	**201.890***
	[0.442]	**[0.436]**	[0.449]	**[0.175]**	[1.648]	**[0.577]**	[0.423]	**[2.576]**
constant	71958	**45678**	26755	**585.920**	-0.22×10^6	$\mathbf{-0.67 \times 10^6}$	-0.67×10^6	$\mathbf{-0.95 \times 10^6}$
	[0.850]	**[0.704]**	[0.372]	**[0.008]**	[-0.386]	**[-0.712]**	[-0.818]	**[-1.305]**
R^2	0.757	**0.770**	0.788	**0.766**	0.844	**0.791**	0.687	**0.731**
$\bar{R}^2$	0.679	**0.697**	0.721	**0.690**	0.706	**0.624**	0.409	**0.516**
DW	2.066	**2.072**	1.948	**1.997**	2.700	**2.322**	2.025	**1.627**
Rho	-0.074	**-0.082**	-0.059	**-0.073**	-0.037	**-0.171**	-0.028	**0.183**

a. The smaller sample size for Hobart and AUSTRALIA warrant the larger values of the DW statistic

Table D.1 continued ...

Variable	AUSTRALIA			
	(1)a	(1)b	(2)a	(2)b
H	-0.031	-0.442	-0.039	-0.039
	[-1.260]	[-1.379]	[-1.444]	[-1.256]
y	35.429	40.829	30.762	41.137*
	[1.576]	[1.748]	[1.496]	[1.907]
hh	110050	131350	104950*	132470*
	[1.707]	[1.835]	[1.919]	[1.955]
CA_1	-0.001	-0.002	—	—
	[-0.316]	[-0.462]		
CA_2	—	—	-0.002	-0.004
			[-0.191]	[-0.282]
MP	19.914	24.646	—	—
	[1.051]	[1.087]		
AQLR	—	—	21.785	15.362
			[1.421]	[1.010]
DN	6687.6	2785.9	8375.5	2606.2
	[0.746]	[0.268]	[1.013]	[0.262]
UC'	-539.680	-254.170	104.580	90.137
	[-0.249]	[-0.105]	[0.050]	[0.038]
$\Delta logPh_{t+1}$	-666.860	-815.370	-602.580	-699.510
	[-1.023]	[-1.079]	[-1.050]	[-1.007]
constant	$-0.180x10^7$	$-0.209x10^7$	$-0.168x10^7$*	$-0.212x10^7$*
	[-1.717]	[-1.826]	[-1.890]	(-1.986)
R^2	0.673	0.609	0.715	0.654
R^2	0.485	0.385	0.552	0.457
DW	2.370	2.439	2.226	2.241
Rho	-0.227	-0.245	-0.164	-0.174

a. The smaller sample size for Hobart and AUSTRALIA warrant the larger values of the DW statistic.

Note: Dependent variable in each case is rph = the real median price of houses; t statistics are in square brackets; * indicates significance at 0.05; the units of measurement of the variables give rise to their extreme relative magnitudes.

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